AIRCRAFT & MISSILES

A Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES JUNE 1961

Muddled Management Mars Hard-Site Construction Progress . . . P 32

Polaris Precision Polished In Complex Simulator . . . P 23

Combined Environment Tests Are Key In BMD's Reliability Plan . . . P 50

ADM. LUIS de FLOREZ, USNR (Ret.)

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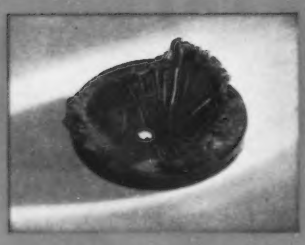
Photos below: material samples exposed to supersonic jet torch at a heat flux of 400 btu/ft²/sec. (approximately 3000°F.)

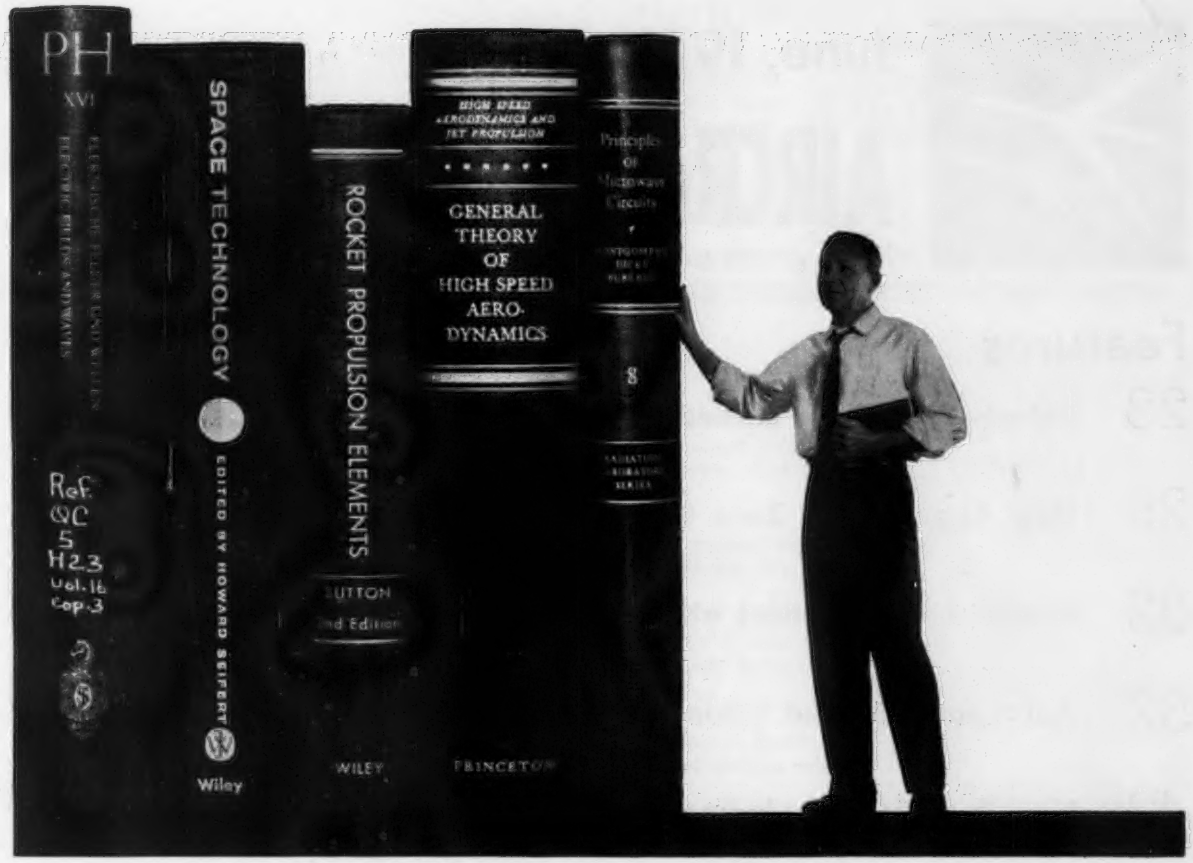
Chrome Composite
15-minute exposure

Graphite
4-minute exposure



Molybdenum
45-second exposure

Chromium
3.5-minute exposure



space systems planning and engineering in a unique role

The scientists and engineers of Aerospace Corporation are in the forefront of advanced planning and general systems engineering. Their unique role: critical civilian link uniting government and the scientific-industrial team developing space systems and advanced ballistic missiles. In providing broad scientific and technical leadership to every element of this team, they are engaged in activities spanning the spectrum from formulating new weapons systems concepts to technical supervision of the over-all industry team performing research, development, and test of missile/space systems. Specific activities include investigation of techniques for improving the state-of-the-art in propulsion, structures, guidance, communications and other engineering skills related to missile/space missions; feasibility studies of new weapons systems concepts and preliminary design of promising systems; formulation of development programs; conduct of critical experiments; technical supervision of the development and test program. Men with these backgrounds are invited to write to Mr. George Herndon, Aerospace Corporation, Room 173, P. O. Box 95081, Los Angeles 45, California.

Organized in the public interest and dedicated to providing objective leadership in the advancement and application of space science and technology for the United States Government.

AEROSPACE CORPORATION

June, 1961 *Volume 4, Number 6*

AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

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NEXT MONTH

MAN AND MACHINE AT MACH 3+ — The glamour bubble of high speed air transport has burst. And problems have been strewn all over the landscape. What are the problems? What are the solutions? Treated in the July edition are such subjects as: (1) The Mach 3 Transport, (2) Convair 990 Electronics, (3) Anti-Collision Systems for Aircraft, (4) Air Traffic Control Modernization, (5) Automatic Landing Systems.

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SPECIAL JULY INSERT

RUSSIA'S MISSILES — What does Russia really have? Listed in this supplement to our Third Annual Handbook Issue are 36 missiles that best intelligence indicates is the basic family of Russian missiles. It includes battle-field weapons and the big ICBM's that have doubled so well in the Soviet space program. It is the first complete rundown on Russian missile weaponry. Data was assembled for Aircraft & Missiles by George J. Geiger, aeronautical historian, through sources in Germany and France.

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Your Datebook

June 6-8
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Instrument Society of America
Royal York Hotel
Toronto, Canada

June 13-15
National Joint Meeting
Aerospace Sciences and American Rocket Society
Ambassador Hotel
Los Angeles, Calif.

June 13-15
Annual Meeting
Aviation Distributors and Mfrs. Assn.
Dennis Hotel
Atlantic City, N. J.

June 14-16
Mechanics Conference
American Society of Mechanical Engineers
Illinois Inst. of Technology
Chicago, Ill.

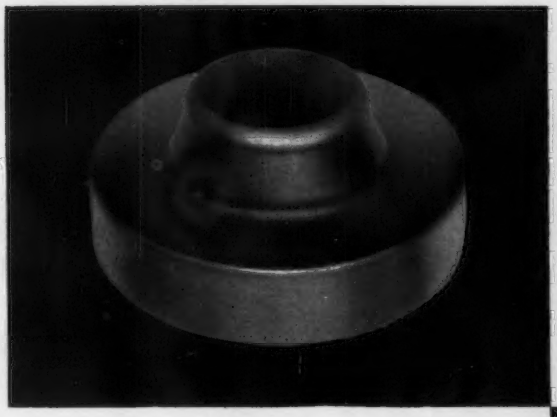
June 19-21
Symposium on Space Flight and Re-entry Trajectories
International Academy of Astronautics
Paris, France

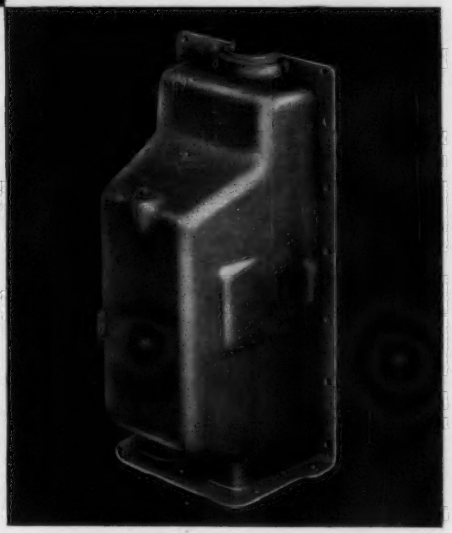
June 26-28
Fifth National Convention on Military Electronics
Institute of Radio Engineers
Shoreham Hotel
Washington, D. C.

June 26-30
Conference on Concepts and Design in Aerospace Electricity
Aerospace Transportation Committee
Benjamin Franklin Hotel
Philadelphia, Penna.

June 28-30
Automatic Control Conference
Instrument Society of America
University of Colorado
Boulder, Colorado

June 28-July 1
Annual Meeting of the Institute of Navigation
Williamsburg Inn
Williamsburg, Va.





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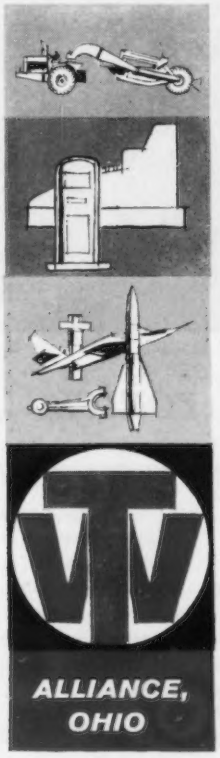

T & W was able to save one manufacturer 54% on the total overall cost of his part. This and many more such examples are the end result of T & W applying a modern concept of ideas and experience which is helping manufacturers in a wide range of industries to *reduce parts cost and improve quality.*

Let T & W try to do the same for you. *Just call or write—or send us a print.*

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in stampings

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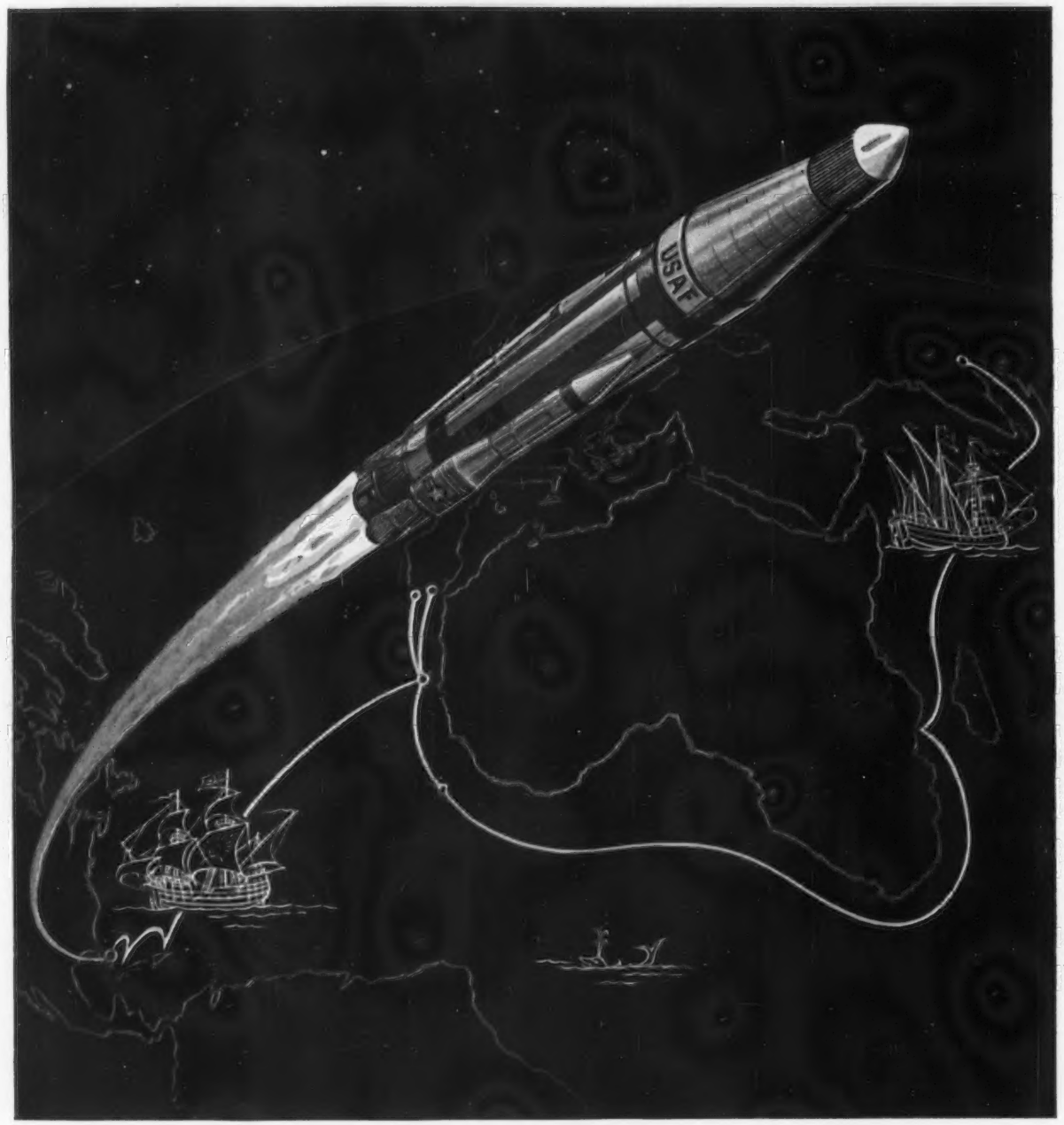

Arma navigates new routes

Navigating with cross-staff and primitive compass, Prince Henry's Portuguese pilots took more than 80 years to find a route around Africa and reach India. The Spaniards took another 20 years to cross the Atlantic and reach the shores of Florida.

Today, missile-borne inertial guidance can navigate such distances in a matter of minutes and pin-point targets nearly half-way around the world. Other advantages of inertial navigation are immunity to outside interference, all-weather capability, salvo firing, and a minimum of ground equipment.

Arma, designer of America's first inertial guidance of intercontinental range accuracy, has these systems in full production with on-schedule deliveries. Although specified for the Atlas missile, the Arma system is equally adaptable to other aerospace programs and space exploration projects.

At Arma, research programs currently are exploring smaller, supersensitive devices for future generations of missile and space guidance systems. Arma, a division of American Bosch Arma Corporation, Garden City, New York. . . . The future is our business. 8321

AMERICAN BOSCH ARMA CORPORATION

Rising Cost of Space "Junk"

Now that the man-in-space fanfare is waning, let's face a cold hard fact. Cash! The planet Earth is becoming a huge junk yard. Automobiles, refrigerators, washers, tin cans, and even fissionable materials in the sea keep adding to the volcano of waste. At least some of this junk has been put to economic good by stripping down or melting. But, the volcano of waste grows larger with each eruption.

Now it appears, since space is so big, we can fill it with "junk." Or, because we lack power, let some of the "worthless junk" fall into the sea.

That so-called junk for space costs money—plenty. Is all of this really unusable? Much of what goes up could go up again—if, we had means of recovery. Each Saturn shot will cost millions. At the moment this does not seem to be of vital importance. Sort of a Space WPA to help the national economy. As systems grow more complex and boosters get bigger, it will cost us more and more. Certainly, the scientific satellites play a long-term and useful role in space. But does the rest of the spacecraft?

Shots planned through 1967, manned or unmanned, into the farther reaches of space show no concrete plan for booster or even mission module recovery. Sure, the men will come back in the takeoff and reentry capsule. This is definitely important. But, what happens to the other millions of dollars worth of hardware? Space "junk."

At times we hear of some rather interesting schemes for "junk" recovery. In most cases, however, the recovery would cost more than the recovered item. Isn't it about time we spend a few dollars on true recovery systems? We should plan entire systems for the future that are completely recoverable. Even the first airplane came back to land with its fuel tank still attached.

Concerning the reentry phase, let us not plan all of our future shots around the parachute. This is rather symbolic of the "court of last resort." Orville and Wilbur didn't use one in 1903.

Tom MacNew
Editor

Reader's Orbit

In Defense of Quality Control

. . . Re: Samuel E. McCrary's comment in Reader's Orbit, May 1961 on "The Fight For Purchased Part Quality." Apparently, reader McCrary has not had the unfortunate experience of learning that all too often purchased parts and components do not meet specification requirements under environmental extremes . . . Some part and component manufacturers are truly concerned about the quality and reliability of their products . . . far too many are *not* . . . This has been demonstrated repeatedly at Convair/Pomona by their admitted failure to conduct specified Group B and Group C tests, and by their demands for additional reimbursement when parts buyers require the conduct of Group B and Group C tests and the submittal of the resulting test data.

MIL-SPECS are not thought to be worthless . . . However, it is generally recognized that many MIL-SPECS are out of date . . . this is clearly pointed out by the ad hoc Group on "Parts Specification Management for Reliability" in the well known "Darnell Report." There are many, many instances wherein the actual operating environments which the item must survive is more severe than MIL-SPEC requirements. Also, many components such as gyros, accelerometers, etc., are not described by a MIL-SPEC. In these circumstances, "Company" specifications must be prepared.

. . . until part and component suppliers, in all integrity, comply with specification requirements and so attain the confidence of missile contractors, there seems to be no alternative but to continue with a QAET type program to detect items which do not conform to specification requirements and which, if used, will contribute to the unreliability of our missiles. By so doing, we missile-plant Q.C. people feel that we truly are "tending to our knitting."

To answer reader McCrary's last question, personnel from Convair/Pomona participated in the preparation of the "Darnell Report" by their membership on the ad hoc Study Group. By this means, efforts have been made lately to bring MIL-SPECS into line with requirements of modern weaponry.

G. M. Ellis
Staff Engineer
Convair-Pomona

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Who's Calling The Plays

Mr. Ellis is correct in his surmise that I have "not had the unfortunate experience of learning that all too often purchased parts and components do not meet specification requirements under environmental extremes." . . . I prefer the proper remedy, i.e., provide the supplier with properly drawn specifications of quality including what must be achieved under environmental extremes, and the requirements for inspection, testing, and qualification at the source. By this procedure items defective beyond acceptable limits are never shipped. In other words QAET should be done as an engineering duty before delivery rather than after, and according to rules established in advance with the supplier in the form of specifications.

Mr. Ellis reiterates complaint that MIL-SPECS are out of date or nonexistent for certain important components, and concludes that "Company" specs must be prepared. The answer to this complaint is quite simple: Draw up the new "company" spec, or "company" amendment of existing MIL-SPEC, according to the rules

and philosophy of Defense Standardization Manual M-200: Use same forthwith for immediate procurement and file a copy with the appropriate government agency having cognizance of the Federal Stock Classification of the item. By this latter act the MIL-SPEC custodian will be alerted to the very latest and most advanced requirements demanded by modern weaponry, and Mr. Ellis will be surprised at the speed with which MIL specs can be updated for all to use.

As described by Mr. Ellis, QAET is a program of product testing, evaluation, and qualification. This is not properly a Q.C. responsibility. It puts Q.C. in the role of establishing product specifications which is a function of engineering or design. The missile plant Q.C. people should "tend to their knitting" which is efficient, lowest cost enforcement of specifications given by engineering.

Quality and reliability are defined by what engineers put into the specifications; quality and reliability are assured through strict enforcement by Q.C.

I'm sure Mr. Ellis and I are on the same team and working toward the same goals; we disagree only as to what plays should be called and by whom.

Samuel E. McCrary, P. E.
Huntsville, Alabama

Small, But Important

. . . it's a small error, but it's important to me. On page 47 of the March issue of Aircraft & Missiles, the contractor for Mercury heat shields is listed as "Berrylium Corp." Even if beryllium had been spelled correctly, the information supplied to your readers is erroneous. The Brush Beryllium Co. supplied the beryllium shields for the Mercury space vehicle.

John G. Price, Manager
Public Relations
Brush Beryllium Co.

It's important to us too, and to a lot of other people. We promise to write fifty times, Brush Beryllium Beryllium Beryllium . . . Co.

Prime Information

. . . we take this opportunity to congratulate you on the fine article "Navy Streamlines ASW Management" (April 1961, The Challenge and the Progress In ASW). Such prime information is always most agreeable to come upon.

Arnold Winter, Manager,
Radiation Systems, Marketing
Radio Corp. of America

MC/SA
MODULAR EXPLODING
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Shown ⅓ actual size is a typical XBS modular system, utilizing a firing module, cabling, explosive cartridge, and a separation link. Of compact, solid state design, the firing module discharges two joules (one mfd at 2 KV) through an exploding bridgewire in less than 10 microseconds. Synchronizing circuits permit simultaneous initiation of multiple modules as required. This advanced XBS modular system provides important advantages of:
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• Greater System Reliability
• Fewer Cabling Problems
• Better Design Flexibility
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3. Second stage destruct system
4. Data package release and ejection device
5. Second stage engine igniter
6. Vernier igniters
7. Stage separation devices
8. Interstage connector (electric, hydraulic, etc.) actuators
9. First stage destruct system
10. Miscellaneous devices (thrustors, pin-pullers, cable cutters, etc.) as required by system
11. Tank pressurization gas generators
12. Guidance and control power gas generators
13. Auxiliary power unit
14. Thermal battery actuators
15. Thrust termination devices
16. First stage engine igniters
17. Missile release devices
18. Umbilical cable releases
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Urethane foam protection for America's first line of defense

In the packaging field, "protection" takes on a new meaning when it's related to the nation's mighty air-sea arm with its fast-growing missile defense systems.

The "brains" of the inertial guidance systems that steer and control such missiles as the Polaris are the intricately adjusted gyroscopes, valued at over $15,000 each. The slightest malfunction caused by temperature variations or shock damage to these small but vital components can make the difference between an accurately-controlled defense weapon—or a dud.

These critical performance requirements are the reason why rigid and flexible urethane foams were selected to cushion and insulate the gyro mechanisms of the Polaris. Standard Plastics, Inc., a leader in urethane foam container design, was commissioned to custom build the package that would protect the gyros against shock loading up to 50 G's, while maintaining, without external heat source, a temperature of 140°F ± 4° for 36 operational hours in a −10° climate. The result is the Transit Heet® shipping container —another "first" in the fast-growing series of packaging "firsts" for urethane foams.

For further detailed case history information on how leading packaging experts are taking advantage of urethane foam's lightweight, shock absorbency and excellent insulating properties, write MOBAY CHEMICAL COMPANY, Code AS-1, Pittsburgh 5, Pa.

f-21

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Mobay is the leading supplier of quality chemicals in the manufacture of both polyether and polyester urethane foams.

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Projects

AEROSPACE DATA CAPSULE I

MISSILES AND SPACE VEHICLES

APOLLO--House Space Committee's vote to add $126.6-million to President Kennedy's space budget would put most of the sum into Apollo project. Apollo and Mercury story on page 41.

CENTAUR--First test vehicle has been shipped to Sycamore Canyon near San Diego for static testing of engines and systems. Two hydrogen-oxygen rocket engines will provide 30,000 lb thrust.

DYNA-SOAR will not use conventional nose landing gear as on X-15. Reentry temperatures are too high for wheels and lubricated bearings. Space glider will use a retractable dish like nose skid, designed and manufactured by Bendix Products Division.

DYNA-SOAR--Wind tunnel program will be greater than any other ever undertaken. About 30 wind tunnels and shock tubes will be used to test vehicle from low speeds up to Mach 25.

F-1 ROCKET CHAMBER thrust level reached 1.64 million pounds for 13 seconds during test at Edwards.

HOUND DOG Missile flights are monitored by North American Aviation Space And Information Systems Division although thousands of miles away from bird. Flight data telemetered to test base is carried over leased telephone line for analysis by missile manufacturer.

JOSHUA--Project is aimed at the development of a light weight ICBM. Marquardt is developing light weight fuel injection system.

KIVA--New rocket motor pushed a monorail sled to a speed of 1880 mph. Solid rocket was developed by Rocket Power for use in sounding rockets and missiles.

LOFTI--By receiving VLF (Very Low Frequency) radio signals from a ground station, the Navy satellite provided science with its first data on the degree of VLF penetration into and through the ionosphere. It was learned that VLF radio waves do pass through the ionosphere into the exosphere. This opens the way for use of these waves for communications from earth to satellite and even from satellite to submarine.

MACE--New rapid-fire launch system makes it possible to fire four missiles in less time than it formerly took to fire one. Martin will convert all current MACE A installations into multiple launching systems. New system reduces the crew needed for the entire operation.

MERCURY-REDSTONE--Congress voted extra funds to step up man in space projects, even before successful Mercury shot on May 5. Mercury and Apollo story on page 41.

NIKE-HERCULES--Production has started on an improved Nike Hercules system with new high powered acquisition radar and target ranging radar. Hercules now has range in excess of 75 miles and its altitude capability is greater than 20 miles.

OAO--An orbiting Astronomical Observatory (Explorer XI) was recently launched with a four-stage Juno II rocket. Satellite measured gamma radition.

SNAP-2--The reactor, being developed by Atomics International, will soon be mated to its power conversion unit for ground testing of the complete SNAP 2 system. Next step is a system with flight configuration mounted in a nose cone for additional ground tests.

SPACE TRACK--RCA is studying the feasibility of tracking satellites with a radar originally designed to gather trajectory data on missiles. The BMEWS tracking radar prototype at Moorestown, N. J., will be used for the study.

TITAN I--Successful first launch from silo at Vandenberg AFB on May 3 adds impetus to Titan II development, and consequently to the Dyna-Soar program.

Projects

AEROSPACE DATA CAPSULE I . . . continued

TITAN II--The Mark 6 re-entry vehicle will have an improved aerodynamic shape. It will be larger than previous nose cones. Aside from being capable of carrying a heavier payload, the advanced Titan missile will have a very quick reaction time, being launched a few seconds after an alert is received.

TRAILBLAZER-1--NASA recently launched a seven-stage rocket which propelled an artificial meteor back into earth's atmosphere at 25,000 mph. Shot was part of a continuing study of the physical phenomena which occur during re-entry of high-speed objects into the earth's atmosphere.

X-15--Engineers traced the vibrations, reported by NASA pilot Joe Walker during the March 30th 2905 mph flight, to the stability augumentation system, which aids the pilot in controlling the aircraft by feeding signals into the hydraulic control system. The system was replaced by a similar system from the number one X-15 for the later flight which reached 3076 mph.

AIRCRAFT

ALARM (Automatic Light Aircraft Readiness Monitor)--Project concept envisions the use of electronic checkout techniques, similar to those used in missile launchings, to determine if airplanes are safe for flight.

B-58 being studied for feasibility of adding more bombs without lowering speed. One plane will be converted by Convair to flight test additional armament.

B-58--Training is being carried out in a new simulator at Carswell AFB. The B-58 trainer, built by Reflectone Electronics, simulates attacks by enemy aircraft and missiles and detection by enemy radar. System includes training in electronic countermeasures (ECM), highly classified area of military warfare.

B95A--New 200 mph Beechcraft Travel Air is powered by two 180 hp Lycoming fuel injection engines. Plane has payload capability of 1645 lb.

BOEING 727 turbofan engines rated at 14,000 lb takeoff thrust now undergoing tests at the Andrew Willgoos Turbine Laboratory. AJT8D engine will be flown later this year in a B-45 flying test bed.

F-100F SUPER SABRE--An F-100F has been modified to simulate the landing approach of boost glide vehicles. This research may eliminate the need for long runways for landing vehicles like Dyna-Soar and the X-15.

HRB-1--Military version of the Boeing Vertol 107 helicopter features a power blade-folding system, which enables the rotor blades to be folded by the pilot in a fraction of the time previously required for manual folding. An integrated system cuts loading time to about eight minutes.

HSS-2--Helicopter weapons systems trainer for the all-weather HSS-2 Sikorsky has been delivered to the Navy by Melpar. The trainer will be used to train crews in communications, navigation, ASW search procedures, tracking and delivery of weapons. The HSS-2 will become operational later this year.

MISSILE MOVING MAMMA--Transport aircraft design envisions craft capable of carrying 120,000 lb cargo 300 mi at speeds up to 200 knots. Six engine transport could transport Saturn-size payload from manufacturing to launch site.

P3V-1--Navy plans to buy nineteen Lockheed P3V-1 Orion patrol bombers in fiscal 1961. With gross weight of 120,000 lb first production P3V-1 reaches 85% flutter speed at 360 knots.

SIKORSKY S-64--All-purpose transport helicopter is the successor to the S-60 Skycrane. First prototype models will be produced later this year. Powered by two Pratt and Whitney JFTD-12 gas turbine engines, the S-64 will have a payload capability of 17,600 lb.

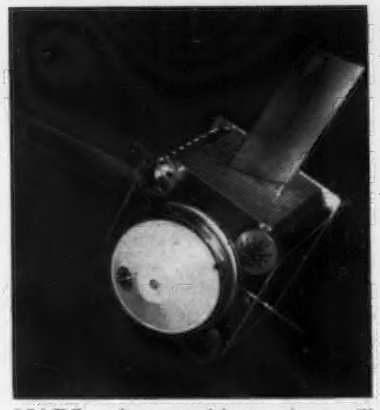
SUPER-CARRIER--USS Kitty Hawk, recently commissioned at Philadelphia, will take on about 100 aircraft, A3D's, A4D's, F3H's, F4H's, and F8U's. Kitty Hawk is first true aircraft-missile carrier. The 1047.5 ft vessel has no armament but Terrier missiles and her aircraft. At flank speed, four propellers will produce 270,000 hp to drive the carrier at 37 kts.

HILLER 12E, light helicopter, topped out upper 93 ft of 200 ft tower in four hours. Conventional methods would have taken five days. This was first time a light helicopter was used for heavy steel construction. Hiller 12E hovered steadily far above ceiling of ground effect with section that weighed 1200 lbs.

SERGEANT, Army's highly mobile surface-to-surface missile, poised for firing from its erector-launcher made by Ling-Temco.

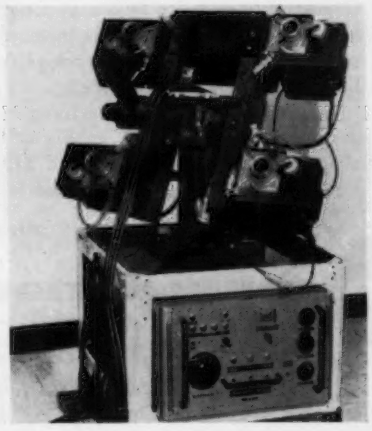
DC-8F Jet Trader, combination cargo and passenger carrier, will be built by Douglas Aircraft Co. DC-8F will carry up to 52,000 lb of cargo and 54 passengers.

GENIE air-to-air missile and F-106 Delta Dart offer strong deterrent team against air attack. More than $120-million worth of Douglas-built Genies and equipment have gone to Air Defense Command Since 1957.



MARS, photographic probe, will eject re-entry vehicle to return exposed film to earth after Mars orbit. Four vanes will provide rotational orientation using light pressure. Probe model was developed by MIT, Thiokol Chemical and AVCO.

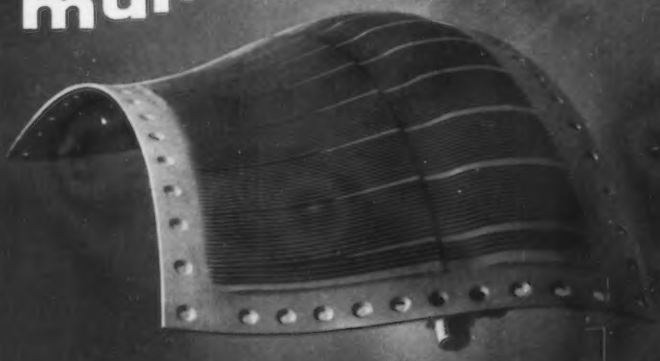
NIKE-ASP upper atmosphere rocket sounding experiments are tracked by camera mounts built by Geophysics Corp. of America. Mount holds four 70-mm cameras.

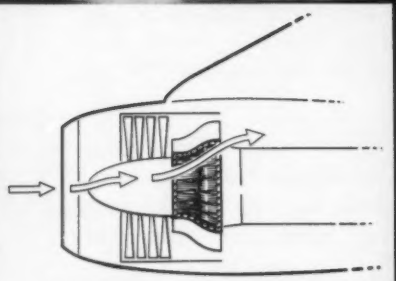


NIKE-ZEUS anti-missile defense system will use massive radar mount like model shown. Continental Can Co. built mounts which weigh more than ten tons.

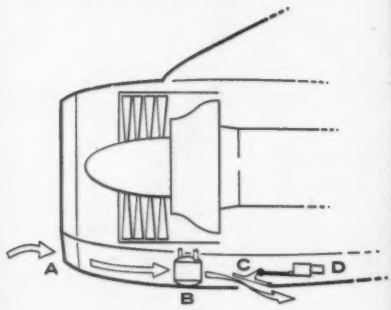
A REVOLUTIONARY CONCEPT IN HEAT TRANSFER DESIGN

multicontoured heat exchangers reduce size, weight and drag...





Multicontoured oil cooler is section of fan exhaust duct



Conventional oil cooling system includes: A. Duct B. Heat exchanger C. Door D. Actuator

This finned surface oil cooler, used for cooling constant speed drive or turbocompressor lubrication oil circuits, is a structural member of the fan exhaust duct. This eliminates the need for air scoops and special ducting.

These installations are already in use on Boeing 707-720B turbofan aircraft and may be shaped to any configuration at extremely close tolerances. Comparable in price to conventional heat exchangers, they are even more reliable and have a longer service life because of their basic simplicity.

Unique manufacturing techniques developed at AiResearch enable this aluminum unit of welded and all-brazed construction to withstand severe structural and pressure loads. Similar units have been developed for non-by-pass gas turbines and ram air ducts. This major breakthrough in heat exchanger design and fabrication is the result of more than 20 years of experience by the company in the design, development and production of heat transfer equipment.

• *Please direct inquiries to the Los Angeles Division*

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

Technical Advances

AEROSPACE DATA CAPSULE 2

R & D BRIEFS

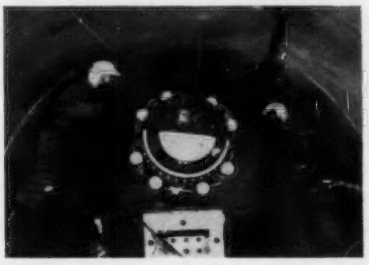
Electronic management systems will aid flight crews manning the air liners of the future. A five-year feasibility study by Douglas Aircraft indicates that routine tasks can be mechanized or automated, freeing the flight crew for more important decision-making.

Simultaneous ignition of Saturn S-IV type scale rocket cluster has been successfully tried at Marquardt where Douglas designed one-tenth scale model was built.

Water launching of heavy vehicles is ready for full-scale launching tests, after the successful launchings of Hydra II, a 40 ft boiler plate mockup. Tests have proved that an object of nearly any weight could be sea-launched a distance limited only by the power of the propellant.

FLEX WING CONCEPT, using wings of cloth or other flexible material attached to a keel and leading edge members in place of conventional wings structures, is based on studies at NASA's Langley Research Center. Flex Wing vehicles could be manned or unmanned, powered or unpowered.

Quiet rocket blast off studies by Air Force included tests of standard 1000-lb-thrust jet assisted take-off rockets and various blast deflectors. Flat plate, curved plate, and conical deflectors considerably diffused and diverted exhaust flow resulting in a decrease in overall acoustic power level of up to 8 dcb.



ZERO-GRAVITY test of a capsule containing liquid hydrogen takes place in a KC-135 jet. Convair is studying behavior of liquid rocket fuel in outer space for NASA.

Unfurlable antennas, which can be packed into small containers and then expanded on control are being investigated by the Air Force. Antennas can be erected by mechanical or pressure techniques after the carrier vehicle obtains orbit.

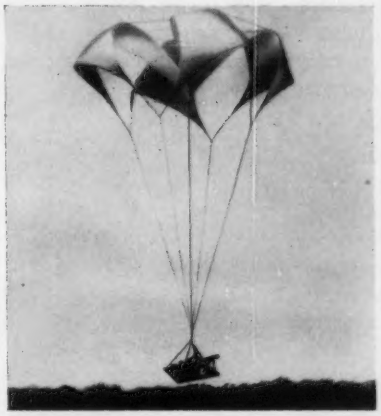
Navy laboratories perform research and development work custom-tailored to specific Navy needs. In doing so they frequently come up with a solution to urgent problems peculiar to naval forces. Such is the case with the new laboratory-developed chemical cleaning system which appears to be effective in salvaging electronic and electrical equipment damaged by sea water, fuel oil and smoke. This system is currently recovering millions of dollars worth of radio, radar and fire-control instruments damaged in the fire aboard the carrier Constellation.

Lunar atlas, containing 30 of the photographs taken by Soviet rocket and four maps of the moon's far side prepared by Soviet astronomers, is now available in English. The translation also gives a detailed description of how the pictures were taken. Order 61-21955 from OTS, U. S. Dept. of Commerce, Washington 25, D. C. ($3.)

Mach 4 escape at 100,000 ft altitudes is being studied by Lockheed. Capsule for mid-60's airairplanes will be built of titanium. Wedge like high drag fins will stabilize capsule during free fall, until parachute is deployed at about 15,000 ft.

EQUIPMENT

Automatic tester, built by Sperry Gyroscope, now in final Air Force evaluation, cuts B-58 bombing-navigation systems checkout time from days to hours.



PARACHUTE capable of vertical pin-point landings is in final test stage. Called the Vortex Ring, it has four sail-type blades of fabric that spin like a helicopter rotor. Pioneer Aerodynamic Systems' design shows promise for cargo air drops, missile recovery and ground braking of high speed jets.

Technical Advances

AEROSPACE DATA CAPSULE 2 . . . continued

Air safety device, known as an "analog-to-pressure converter," is used before flight to correct and calibrate plane's instrumentation to insure near-perfect altimeter and air speed readings during flight. Portable unit was designed by Molectronics.

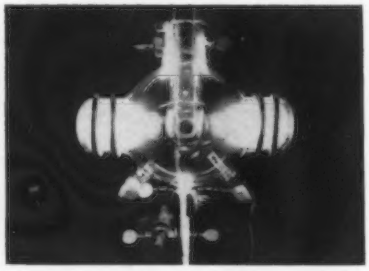
Electrical system, developed at NASA for checking out and launching the Saturn booster uses six or seven times as much hardware and instrumentation as the Jupiter system. Equipment will be used initially on SA-1 flight.

Image Storage Translation and Reproduction (ISTAR) system would enable space vehicles to obtain and transmit back to earth clear, detailed photographs even in extremely dim light. Chance Vought ISTAR can store images over a long period of time.

Airborne radar-jamming system will be tested by Air Force. Sperry system employs traveling wave tubes for jamming over a broad frequency range and a computer for automatic operation.

SUPER RADAR SYSTEMS produced by Sperry Gyroscope, will be tested by lightweight balloon-borne aluminum spheres. Use of sphere eliminates costly testing on actual aircraft.

Camera, mounted in pods at each wing tip of F9Fj drone targets, will record how and why guided missiles hit or miss their targets during tests. When a hit is scored, the pod and cameras, built by Photo-Optical Div. of Consolidated Systems, are recovered from the drone and the filmed records are removed.



PLASMA MODULATION TUBE may help overcome communication blackouts during vehicle re-entry. Melpar developed device is designed to simulate plasma sheath conditions in the laboratory where studies can be made to overcome the problem.

Seconds can be broken down into millionths with Sperry Gyroscope timing system, which could be used to detect and pinpoint space vehicles and aircraft, as well as synchronize sensing devices monitoring all-important missiles tests and to survey offshore islands and remote areas with extreme exactness.

MATERIALS

Chlorine triflouride and triethylaluminum for ignition of hydrogen-oxygen rocket combustor were subject of study at NASA's Lewis Research Center. These chemicals, as well as liquid florine or trimethylboron, have equally satisfactory ignition characteristics.

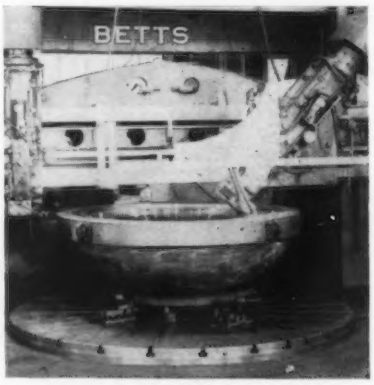
Nuclear fuel in the form of glass fibers is being studied by Soviets. Nuclear fuel elements made of glass fibers containing oxides of uranium, plutonium or thorium would have advantages of chemical stability, thermal stability and heat resistance, making it possible to operate at temp up to 1000° C.

Solid propellant development will reduce the weight of rocket motors and increase energy output about six per cent according to B. F. Goodrich Aviation Products. C-123 formula "has a 15 lb-sec increase over present rubber-based fuels."

PRODUCTION

Universal filament winding machine developed by Marmco R&D Div. of Telecomputing Corp. can produce a wide range of shapes using glass, in wire or tapes.

Powder metallurgy technique, developed by Union Carbide Metals, can be used to produce refractory metal parts on a short run basis.



EXPLOSIVE FORMING tool needed to produce a 78 in. die parabolic missile reflector at Ryan Aeronautical, resulted in the largest ductile iron casting ever poured. Machining was done on a Betts vertical boring mill using a Mimik hydraulic tracer.

De-salting process feasible for municipal applications according to General Electric. Recent tests of thin film water distillation process show a significant increase in the heat transfer capability for industrial installations as well.

Procurement

AEROSPACE DATA CAPSULE 3

Subcontract Sources

Proposed unclassified NASA research and development contracts leading to prime contract awards of $100,000 or more will be published in the Dept. of Commerce's daily "Synopsis of U. S. Government Proposed Procurement, Sales and Contract Awards." Subscription rate is $10 a year by regular mail, $28 via air mail, from U. S. Dept. of Commerce, Administrative Service Office, Room 1300, 433 W. Van Buren St., Chicago, Ill.

Bigger Cut to Industry

The Navy will require more commercial overhaul and maintenance. Ashley L. Monroe, Assistant Director, Aircraft Engineering Div., Bureau of Naval Weapons, told a recent meeting of the National Aeronautical Services Association that there are "not enough in-house available man hours" to keep up with the new array of aircraft types.

Business Moves

Atlantic Research Corp. has become part owner of Nuclear Science and Engineering Corp. Atlantic's Nuclear Engineering Div. is constructing a new "hot" laboratory at the company's Edsall Road location.

United Technology has opened a Research and Engineering Center in Sunnyvale, Cal., and a Development and Test Center near Morgan Hill which was constructed to handle the fabrication and testing of some of the largest solid propellant rocket motors currently being built.

Chance Vought Corp. will merge with Ling-Temco Electronics, Inc., if stockholders agree at meeting later this month.

Philco Corp. has moved its expanding Communications Systems Div. into a new building at Fort Washington, Pa.

IBM's new Thomas J. Watson Research Center at Yorktown, N. Y., will house some 1500 scientists and supporting personnel for the study of computer science.

Astrosonics, Inc., has created a new division, Astrosonic Development Laboratories, for applied sonic research at Syosset on Long Island, N. Y.

Contracts

Aerojet-General—$10,893,082 from Army for additional rocket motors for the Hawk missile.

Marquardt Corp.—$4-million from Air Force for research and development of a nuclear ramjet engine, Project Pluto.

Temco Missiles & Aircraft—$1.5-million for erector-launchers for Army's Sergeant missile.

Sperry Utah—$2,479,500 for continued development of Army's Sergeant surface-to-surface missile.

Epsco, Inc.—$2.4-million from Martin-Denver for telemetry equipment for Titan II.

Avco Corp.—$4-million from Convair for components to be used on Convair 990 jet transports.

Control Data Corp.—$4-million from General Electric for Polaris submarine computers.

General Electric Co.—$4.5-million for production of Mark 1 inertial guidance systems for Navy's Polaris missile.

Hycon Mfg. Co.—$2-million from Navy for automatic test equipment for Terrier and Tartar missiles.

Kollsman Instrument Corp.—$9.5-million from Air Force for automatic astro compasses to be installed on Boeing B-52 jet bombers.

Philadelphia Gear Corp.—$2.5-million from General Dynamic Corp. for development of gear drives for 600 ft radio telescope being built for Navy at Sugar Grove, W. Va.

Raytheon Co.—$56,984,827 from Army for Hawk missiles and ground equipment.

Magnavox Co.—$10.5-million from Navy for P2V and P3V ASW radar units.

Western Electric Co.—$23,222,202 from Army for production of Nike Hercules missiles.

General Electric Co.—$28-million from Air Force to develop Mark 6 nose cone for Titan II.

Bendix Corp.—$17-million from Army to develop the communications system for Project Advent, 24-hour microwave communications satellite.

Sperry Rand Corp.—$8.5-million from Navy for inertial navigation equipment for ballistic missile submarines.

Thiokol Chemical Corp.—$4,936,812 from Army for various missile motors.

Interstate Electronics Corp.—$9.5-million from Navy for test instrumentation systems for Polaris submarines.

Bell Aerosystems Co.—$10-million for automatic landing systems to be used on Navy carriers and as land based training devices.

Sylvania Electric Products Inc.—$5-million for communications systems for Navy's Polaris submarine.

Burroughs Corp.—$11-million from Air Force to build data processing systems for the SAGE (Semi-Automatic Ground Environment) system of continental air defense.

Bendix Corp.—$1-million for emplacement systems to lower the Minuteman ICBM into underground launch tubes.

NEW SPACE AGE FUTURES FOR

engineers

in CONNECTICUT or FLORIDA

Pratt & Whitney is expanding its operations at their East Hartford, Connecticut, Facility and Florida Research and Development Center in advanced research and development projects and long-range product planning. Current programs include: the LR115-liquid hydrogen rocket engine for Centaur and Saturn and the J58-Mach 3 turbojet engine. Advanced Research and Development programs are exploring the fringe areas of technical knowledge in magnetohydrodynamics, thermionic and thermo-electric conversion, hypersonic propulsion, fuel cells and nuclear power for military, space and industrial applications. Openings exist at all levels of experience for engineers and scientists who want to work as part of a team dedicated to maintaining Pratt & Whitney's position of leadership in the future.

ADVANCED PROJECTS AND APPLIED RESEARCH GROUPS

For new research and development projects and long-range product planning in the fields of propulsion and power systems and their applications.

- Aero Thermo Engineers—for performance and optimization studies of all types of advanced power plant and vehicle systems including air and space craft, missile aircraft, marine and industrial applications.
- Applied Science—for advanced research and development work in the fields of nuclear, chemical and direct conversion equipment. Openings exist at BS through PhD levels in Engineering or Physics.
- Nuclear Engineers—to work with advanced concepts in reactor systems and components.

ROCKET ENGINE TEST SUPERVISORS *(Florida only)*

Experience required in the technical and administrative direction of rocket engine test complexes. Plan, schedule, co-ordinate and supervise engineers and support personnel. Broad knowledge of test equipment, facilities design and construction, test operations and support activities required.

MEHANICAL DESIGN ENGINEERING

Engineers to engage in the mechanical design of propulsion systems, including turbojet, turbo fans, solid rockets, liquid rockets, magnetohydrodynamics, nuclear and fuel cell power applications. Must have a minimum of 5 years' related experience.

ANALYTICAL DESIGN ENGINEERING

Engineers with experience in the analysis of propulsion systems design, including the fields of advanced structures, stress analysis, vibration, compressor analysis, turbine analysis and combustion and heat transfer. Must have a minimum of 5 years' related experience.

EXPERIMENTAL ENGINEERING

BSME's or AE's with 2-5 years' experience to conduct and direct rocket engine and component development. Of particular interest are those who have had engine performance, fuel and control systems experience on advanced propulsion systems.

ELECTRICAL ENGINEERS

2-3 years' experience in electromechanical, electro-hydraulic, and electro-pneumatic servo control systems; systems design, trouble-shooting, and calibration; should have good mechanical background.

TEST FACILITIES ENGINEERS *(Florida only)*

Facility engineers and test equipment designers with 4-7 years' experience in the turbojet and rocket fields.

Please submit your complete resume, including minimum salary requirements, to:

MR. P. R. SMITH, OFFICE 40
PRATT & WHITNEY AIRCRAFT
410 MAIN STREET
EAST HARTFORD 8, CONN.

— or —

MR. J. W. MORTON,
OFFICE 40
PRATT & WHITNEY AIRCRAFT
WEST PALM PEACH, FLORIDA

All replies will be handled promptly and in complete confidence.

PRATT & WHITNEY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Market Planning

AEROSPACE DATA CAPSULE 4

The Biggest Bill

A quickened pace and a longer stride will result from the recent Congressional Armed Services Committees bill on defense spending. It is the largest authorization bill in the history of Congress. About $12.5 billion, and all for aircraft, missiles, and ships.

Underlying philosophy of the bill is summed up by House Committee Chairman, Carl Vinson: "while it may be true that the ICBM may at some time in the future provide our principle means of deterrence, and our greatest offensive capability, that time has not come as yet. . . ."

The House Committee restored B-52 and B-58 to production status by allowing $383.2 million. In approving the bill, the Senate added $132 million for B-52's. The last fifteen C-135 aircraft MATS buys will get new turbofan engines instead of turbojets. $21.2 million is allowed. And three special, long-range jets for top government officials will be bought with $25 million in new funds. The specific design, VC-137A, DC-8, or Convair 990 has not been disclosed. Navy will get $10 million additional to buy two nuclear powered missile frigates instead of three conventional missile frigates.

By a slim, two-vote margin the House decided to abide with President Kennedy's B-70 cutback. Eisenhower had asked for $358 million, Kennedy requested $220 million. This battle is far from over.

Highlights of the Navy ship building and conversion budget are 35 new ships, 16 small vessels, and modernization of 22 existing ships. The 29th Polaris submarine has been stepped up to a 1964 completion date from the earlier 1967 date.

This is how the respective services fare under this bill which started out as a $10.572 billion Eisenhower request, was jumped to 11.974 billion by Kennedy, and now stands at $12.5 billion.

AIRCRAFT:	
Army	$211,000,000
Navy and Marine Corps	$1,585,600,000
Air Force	$3,802,200,000
MISSILES:	
Army	$550,800,000
Navy	$606,400,000
Marine Corps	$27,000,000
Air Force	$2,792,000,000
NAVAL VESSELS:	
Navy	$2,925,000,000

Space Spending "All Systems Go"

Space skeptics had best take cover. Those who are geared for it can get ready for a flurry of contracting activity. Success at Cape Canaveral on May 5 will give the man-in-space project the shot of adrenalin it has long needed.

Just a few days before Cdr. Alan Shepard flew an "A-OK" ballistic trajectory in a Redstone boosted Mercury capsule, the House Space Committee tentatively decided to increase President Kennedy's request for space money by $88.7 million. Over $50 million of this amount was set aside for man-in-space.

Just a few hours after the Mercury flight, the President informed the nation that as great an achievement as the first man-in-space shot was, it didn't change our position in the race . . . "we are behind." He said he would again ask for more money.

Kennedy's original budget request was for about $1.2 billion. The latest House action has raised the budget to $1.3 billion. By the time the President raises Congress back the kitty could conceivably approach $1.5 billion.

Where Money Goes — Where will the new money go? Apollo, Rover, and big solid boosters studies.

Increased Space Funds (millions)	**From**	**To**
Apollo	$29.5	$72.1
Rover	17.5	26.0
Solid Boosters	3.1	18.1

Whether Project Apollo is the correct or incorrect approach to manned space exploration is still debatable from a technical stand point. But NASA's position is now firming up. A successful Mercury orbit will make the ballistic reentry technique untouchable for a few years.

Don't expect Air Force to take it all sitting down, however. Dynasoar, Aerospace Plane, and the merits of high-lift reentry techniques will be subjects of some heated discussions in the next few months.

More activity can be expected in nuclear propulsion too. There is a growing realization that this kind of powerplant is a must for the long haul in space. The $26 million Rover budget could be boosted when the House Science and Astronautics Committee starts hearings anew next month.

R/M ASBESTOS-PHENOLICS

hottest weight-savers for hot missile parts

Pound for pound, R/M asbestos-phenolic missile parts give you far greater strength and stability at extreme temperatures than metals.

This amazing family of asbestos reinforced plastics retain their good mechanical properties for the time-temperature relationship required for missile parts. At elevated temperatures where other materials fail, asbestos-phenolics made by R/M provide superior strength retention and controlled ablation.

R/M asbestos-phenolics are noted for their low thermal conductivity and diffusivity. Because they are based on extra-long spinning grade asbestos fibers, they assure high strength-to-weight ratios, superior shock resistance, and uniform ablation.

Felts, mats and molding compounds are available from R/M for prompt shipment in production quantities. They are backed by comprehensive technical data and know-how. Write for information and engineering help.

Nozzle of R/M Style 150RPD Pyrotex® molding compound.

RAYBESTOS-MANHATTAN, INC.

Reinforced Plastics Department, Manheim, Pa.

SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL

Circle 11 on Inquiry Card

Management

AEROSPACE DATA CAPSULE 5

AIR FORCE SAVINGS

A $73-million reduction in future Air Force requirements for motor vehicles has been realized as one result of a new Air Force program called "Money Tree." A conference of materiel officers indicated a need for improved materiel management discipline.

Re-examination of vehicle requirements resulted in the elimination of 70 types of equipment. This reduces future Air Force requirements by 14,076 vehicles.

Basically sound original designs have permitted a high degree of standardization during the four years of production on the KC-135 tanker, according to Maj. Gen. W. A. Davis, commander of the aeronautical system center at Wright-Patterson AFB, Ohio. The current average unit price for the basic airframes is about one-third of the average unit price of the first 100 airplanes produced.

SATELLITE BATTLE

Communications Satellites, Inc., new GE subsidiary, and American Telephone and Telegraph Co. have both applied to the FCC to establish a worldwide communications satellite system.

AT&T contends that licensed communication carriers have the right to develop and own the satellite facilities and that they should choose equipment to be used. GE wants checks to preclude domination by any one communications carrier or aerospace corporation.

Proposals call for a microwave relay service to all FCC regulated carriers, using space satellites.

GE estimate places cost of a complete worldwide system with 120 ground stations between $400 and $500-million. Initial ten-satellite, 20 ground station system could be operational by 1965.

ORGANIZING RELIABILITY

Reliability handbook, published by Rome Air Development Center (RADC), contains specifications prepared by the Center covering both development and production models of electronic equipment. RADC is responsible for all R&D related to AF ground electronic equipment.

Problems in organizing a reliability program, the role of management in reliability programs, the mathematics of reliability and reliability production are discussed.

The handbook ($4.) PB 161 894 and latest revision ($3.50) PB 161 894-1 are available from OTS, U. S. Dept. of Commerce, Washington 25.

DOUGLAS IN ITALY

Two prototypes of a Douglas El Segundo designed six place twin jet will be detail designed and built by Piaggio of Genoa. First flight of jet, designed to cruise at 500 mph at 40,000 ft, will be in 1962. Italian Air Force is contributing towards the development with an eye to buying production models.

INTERNATIONAL POOL

Wilcox Electric Co. has signed a long-term exclusive agreement with Marconi's Wireless Telegraph Co., Ltd., of England, to "pool the technical resources and long experience of the two concerns in the field of aviation electronic equipment."

MANAGEMENT QUOTES

Elliot Mitchell, asst. director for propulsion, NASA: "While nuclear and electric propulsion are attractive longer range candidates for high efficiency upper stages and spacecraft over the next ten years, it appears likely that chemical systems will be the practical launch vehicles and probably our principal system for spacecraft."

Rep. Overton Brooks, (D-La.) Chairman, House Committee on Science and Astronautics: "No matter what course the nation takes with respect to the development of huge chemical rockets, we cannot afford to ignore nuclear rocket development."

Dr. Howard G. Schutz and Richard A. Duffee, Battelle Memorial Institute, reported at a meeting of the Institute of Environmental Sciences: "Atmospheric conditions which are normally considered to have insignificant effects on performance or, at most, are regarded as laboratory curiosities, may become of paramount importance in the sealed capsule environment."

Lt. Gen. B. A. Schriever, Commander AFSC: "When you combine a contest of ideologies with a technological explosion, you get an intense competition . . . a competition in which no prizes are given for second place."

Hugh L. Dryden, NASA deputy administrator, addressing the National Aeronautical Meeting: Tests at Langley Research Center have indicated . . . "that for each half inch of slush or water on a runway, approximately 1000 ft more of ground run is required for a jet transport to take off."

Maj. Gen. Frank A. Bogart, newly appointed comptroller of the Air Force, told 550 top business executives during Sperry Gyroscope Co. cost reduction seminar: "Industry has lost a half billion dollars in defense business in the last two years and the nation an equal amount in hardware." Loss came about when Congress, unimpressed by DOD cost reductions slashed appropriations by $465-million in F.Y. 59 and 60.

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COVER STORY

ADM. de FLOREZ, USNR (Ret.)
Sire of Simulators

Luis de Florez took the Navy by storm. At the age of 50, the five-foot fireball "secured" a commission, and orders to flight school. When he swooped into Pensacola out of an overcast sky, stepped alone from his own aircraft and announced, "I am here to learn to fly," the Navy knew it had a tiger by the tail.

De Florez' fortune and reputation had already been established as an engineer. But he went on to new fame. He revolutionized training methods for men who fly and men who operate complex ground equipment. He sired the simulator. His electronic devices were used in WWII to teach men gunnery, navigation, piloting, recognition, communications, etc.

Now Navy has Polaris. And it is training crews de Florez-fashion. When the 29th Polaris submarine slides down the ways in 1964, its crew will be ready. The crew will have trained for the use of what some call "the ultimate weapon" in the "ultimate simulator" . . . an electronic replica of the submarine's nerve center. De Florez did not design this device, but symbolically the contract manager was the Naval Training Devices Center he founded with a $50,000 budget.

Of modern weaponry de Florez says, ". . . the machines are useless without the men." He thinks training simulators are not getting their due of Aerospace Ground Equipment funds. ". . . five percent of any weapon system cost should be set aside for training hardware."

Polaris Precision Polished In Huge Simulator

by John P. Kushnerick

Putting Polaris on target is basically a navigation problem. The first 9000 miles the missile travels in the submarine are just as important as the last 1200 to 2500 miles it travels in flight. Without exact knowledge of the submarine's location the Polaris mission could fail. Some of the most precise navigation ever performed will therefore be demanded of Polaris-launching submarine crews. And the crews must be ready as each of the 29 submarines and their nuclear arsenals become complete hardware. Crew training is part of the concurrency concept in Polaris. How is it all done? With complex electronic simulators. These training devices are taking on a vast new importance in the family of Aerospace Ground Equipment.

Nav Simulator — The first of three huge navigational training systems Navy will procure has been installed at the U.S. Navy Subschool in New London, Conn. The other two will be located at different training stations. Together, these simulators will play a major part in the selection and training of about 6000 crew members while these ships are still being built. When each crew goes to sea it will navigate under the same star sky it has practiced with for many hours in the simulator. Electronic programming makes it possible to "look forward" in time to duplicate any celestial umbrella at any place in the world at any given time.

The navigation simulator was developed and built by Reflectone Electronics, Inc., in close cooperation with Electric Boat Co. Together with other systems which duplicate the complex diving and missile launching equipment in the submarine George Washington, this simulator is one of the most complex training systems ever constructed. The simulator - complex can be used to train any portion or all of the crew in certain phases of Polaris operation or missile countdown and firing. The navigation simulator permits these operations at "different parts of the globe."

Key Equipment—Key pieces of navigation equipment in the submarine and simulator are:

- Three SINS's (Ships Inertial Navigation System)
- N A V D A C (Navigational Data Computer)
- A Star Tracking Periscope
- LORAN Equipment

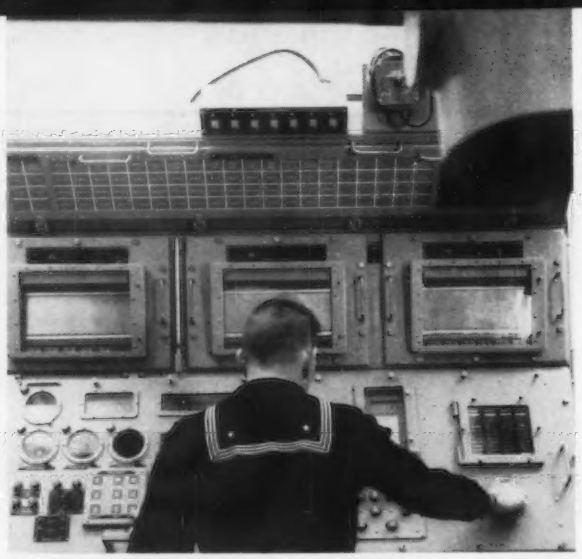
Reflectone Electronics devised means of simulating the actual operation characteristics of this navigation gear. Complex computer studies were used to probe the characteristics and extent of errors inherent in each piece of equipment.

It was also necessary for Reflectone to design an artificial star sky into the star-tracking periscope, and devise a motion simulator to duplicate ocean currents and the submarine's motion through the water.

SINS Simulator — The George Washington gets its most accurate navigational data from the three Ships Inertial Navigation Systems (SINS) on board. It is now quite well known that these units are heavy, accurate versions of the Navaho missile guidance developed by Autonetics Div., NAA. Despite their great precision these units generate small inaccuracies. As a result each gives a slightly different reading. Readings must be compared with each other and with data from other equipment to establish the submarine's position with the accuracy required for a Polaris launch.

The equipment operator must learn to select the SINS data he thinks most accurate, since the NAVDAC which accepts and digests this data will take only one input at a time. This could be a vital decision and could significantly

POLARIS SUBMARINE simulator now installed at Navy Subschool, New London, Conn., is used to train crews concurrent with weapon system construction. Complex navigation simulator (background) is used in conjunction with diving trainer (foreground).



NAVIGATION CONTROL CONSOLE shows status of all major equipment in the nav-system. This includes 3 SINS (one visible upper right), NAVDAC, and star-tracking periscopes. Position readout is given in longitude and latitude on numerical counter for each SINS.

affect a ship's course.

It is necessary to degrade the SINS output data in a highly realistic manner in order to simulate gyro friction, accelerometer malfunctions, and other errors apparent in the actual submarine. These errors may be extremely small or they may be gross, indicating a malfunctioning SINS. The simulator provides means for inserting the varying degrees and rates of error into the several systems of the simulated SINS equipment, to produce latitude and longitude readouts.

Course Generator—In the simulator, an instructor controls a course generator that produces mechanical and electrical signals representing speed and heading of the vessel. Ocean currents can also be simulated by this device. The exact speed and direction of known currents are used in a specific geographic problem.

Indications presented to the navigators in the simulator, however, are degraded by the inherent errors of the actual systems as a function of lapsed time from the last check or correction point. It is considered essential that navigation crews can be given training in calibration and resetting procedures for the equipment.

When utilized as a navigation trainer only, ship's heading and speed through the water are inserted into the system by the instructor from a ship's characteristic simulator. However, when used with the diving trainer this data is obtained from the computer associated with the diving trainer. Ocean currents may be manually set in by the instructor or set automatically.

The course generator is an analog system that makes use of velocity servos. Speed through the water is inserted as a voltage. The higher the voltage the greater the speed.

Ocean currents are also introduced as a voltage.

Heading is set into an analog resolver. Direction of ocean currents are resolved into Velocity ± North, and Velocity ± East. These components help to form a vector indicating course of the vessel in the water. Input data is derived from charts of the area in which the sub will operate. All inputs are degraded to simulate actual errors.

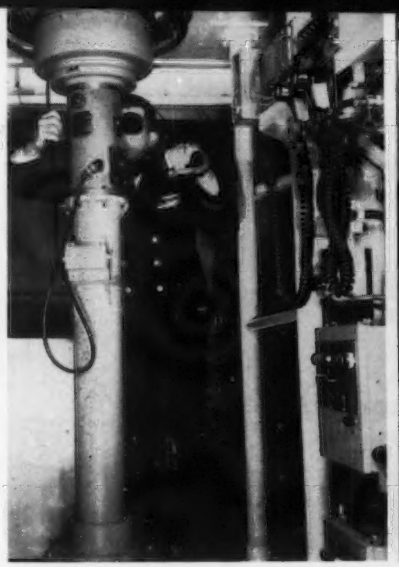
The system converts these data and automatically plots the ship's course on a chart as an output. This output is fed to the simulated SINS equipment.

NAVDAC Computer—The Polaris submarine's NAVDAC, a digital computer, relieves crews of the time-consuming task of recording and computing navigational data. It contributes enormously to speed and accuracy.

Simulating this equipment was no small task. The design approach however was clever. Rather than simulate the entire system only the output, derived from the course generator, was created.

In the actual submarine the outputs of the several navigational devices, such as the SINS, and LORAN-C, are fed into the NAVDAC computer. These inputs are either automatically or manually inset and the function of the computer is to compare and determine the differences in latitude and longitude of the several systems and to print out these differences so that the navigator can determine his most probable position. In the trainer, a similar operation is conducted and the most probable position of the vessel is determined from the printed or indicated data.

Artificial Star Sky—The navigation trainer also duplicates the periscope system aboard the George Washington. This includes a Type 8 periscope for celestial observation, and Type 11 star-tracking periscope.



STAR SIGHTS are taken on periscopes. Type 8 (at left) is used for scanning and location of star to be sighted. Type 11 (at right) is used for precise sightings. Gear at right of Type 11 is part of optical alignment for periscope and SINS. Reflectone Electronics built miniature planetarium with 60 principal stars into periscope.

THE BIG DECISION for which Polaris crew trains comes when "Fire" button is pressed on commanding officer's control panel. Panel gives status of the 16 missiles.

An artificial sky with all principal navigational stars (50 to 60) was incorporated into the periscope system. It is a miniature planetarium. Astro-computers position the sky to allow fixes to be taken for almost any navigable position on the globe for any time or date in the past, present or future. This equipment also incorporates a "star memory system" which controls the automatic positioning. The stars can be positioned according to a selected time of year, time of day, latitude and longitude, as well as instantaneous heading of the vessel.

The view seen by the navigator is that which would be seen in actuality through the periscope as it revolves through its 360 deg arc. Readings taken on the simulated Type 8 periscope are correct to within approximately eight minutes of arc. Readings taken on the simulated Type 11 periscope, however, are accurate to within a few seconds of arc.

When the navigator observes the heavens through the submarine's two periscopes, it is possible to correct plotted location and remove accumulated errors from the several navigational devices.

Operation of Periscope — The operator scans the sky with the Type 8 periscope, selects the stars on which he will sight, and then sights with the more accurate Type 11 periscope. The assigned index numbers of the stars being sighted are set into the NAVDAC computer. Each star's number and position are stored in the computer's memory. The computer then aligns the optical system of the Type 11 periscope in accordance with where it thinks the ship is from data previously set into the NAVDAC. The selected star is then viewed. If position data are correct, cross hairs will be on the star. Any deviation between the star image and cross hairs represents "error" from actual position.

The operator then manually repositions the crosshair precisely upon the location of the star. Automatically the error is compensated, and computer corrections are provided by pressing a mark button each time perfect coincidence is achieved. Data are inset into the computer which corrects for motion of the vessel during the time the fix is taken to develop continuous precise positional data.

With these new positional data the fix operation is repeated for two or three more stars. These data are set into the computer as the actual, precise location of the submarine at that exact time of day. The ship's navigator then repositions the three SINS's to correct for the accumulated errors and adjusts the several remaining units of navigational information. As the vessel runs submerged, the navigation system maintains a very precise "most probable location," considering the errors and variations inherent in each of the several pieces of equipment.

Equipment Details—The entire navigational system consists of three sections: the actual navigation center, the instructor's console, and the computer room.

The navigation center contains the equipment (SINS, NAVDAC, etc.) just described.

The instructor's console contains equipment for controlling the operating parameters of the entire navigation problem and each piece of equipment.

The computer room houses the heart of the simulator system—the logic equipment that supplies information parameters, compares relationships, and feeds data to the navigation center.

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New Approach To Zero Gravity Tests

Lockheed device simulates "effects" not "conditions" of zero G; All human sensory cues nullified by flotation and rotation; Could be basic tool for selecting and training astronauts

by Raphael B. Levine, Ph.D.,
Human Factors Research, Lockheed-Georgia

Weightlessness may be one of man's biggest problems in his first space journeys. This condition is one of the most difficult to design against. Because, weightlessness can not be studied in detail prior to actual space flight.

A "Null-Gravity Simulator," developed by Lockheed's Georgia Div., is, however, expected to provide answers to many of the problems. The device is designed to nullify all man's important sensory cues to gravity. Visual, mechanical, and inner-ear balance cues will be reduced to negligible levels.

Simulators — To duplicate a null-gravity situation on Earth, two approaches are possible. It is necessary either to: (1) Cancel the gravitational field completely in the vicinity of the subject, or (2) Support the subject in the field in a manner which eliminates the forces of weight both at the surface of the subject and throughout his volume. It is not possible to achieve either of these, except in the case of homogeneous magnetic specimens which can be supported, molecule by molecule, in a magnetic field of force exactly equal to that of the gravitational field.

But, duplication of the effects of null-gravity conditions and duplication of the null-gravity conditions are two different problems. To solve the former, we only simulate null gravity; we do not produce it.

The role of simulators which reproduce many of the essential conditions of actual operating situations has grown in importance as the complexity of man's function in man-machine systems increases. Successful simulators not only make it possible to study man's reactions to new and difficult situations, but also provide a means by which man can learn to react effectively to new environments. Dangers and costs associated with learning in the actual environments is removed.

Lockheed's simulator is designed to duplicate all or most of the important psychological and physiological effects of true long-term weightlessness. This will be of immediate practical importance in the selection of future astronauts. Training the selectees could also be done in the facility. Of no less importance will be the information obtained concerning the function of physiological and psychological processes in the weight-deprived state. Besides the basic knowledge of sensory and metabolic processes, interesting in itself, such information can be applied to the design of many special life-support systems necessitated by null-gravity existence.

Before looking at how this device simulates the null-gravity condition, some of the terminology of weightlessness and its simulations should be understood—weightlessness, null gravity, zero gravity, and free fall.

Weightlessness—Weight is one of the more noticeable effects of gravity. This phenomenon is the force which a mass exerts on a surface supporting it in a gravitational field. In the case of a finite body, each layer of molecules in the body is supported by the layer below it, so that forces exist throughout the body. When the basic support is removed, the body falls freely, and the force which we know as "weight" vanishes. This is true not only at the surface of the body, but throughout its mass, as well. Under such circumstances, this aspect of gravity, as we normally experience it, has been nullified, even though the gravitational field itself continues to act, unaltered. We, therefore, speak of free fall as a "null-gravity," rather than a "zero-gravity" state.

"Free-fall" is exactly what the term implies: a falling freely towards the center of all masses acting on the body. In the case of a body released above the surface of Earth (as in a rocket when the motors are shut off) it begins im-

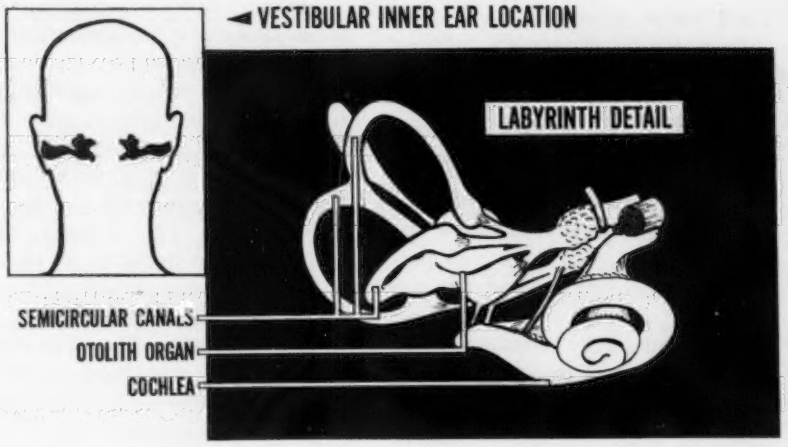
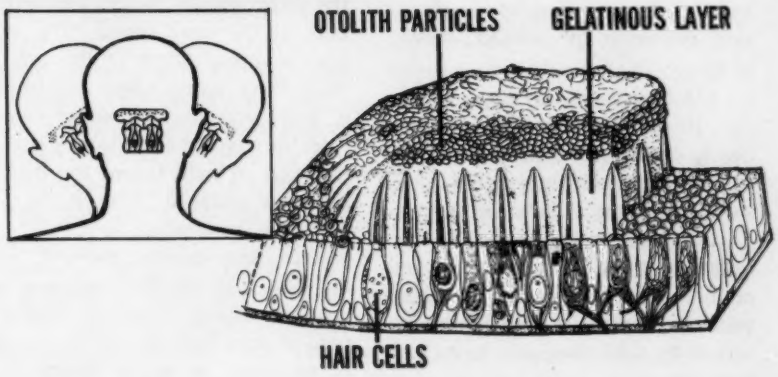


FIG. 1. SENSORY CUES for gravitational orientation arise in the inner ear. Nullifying the cues that the inner ear gives to the brain is important in zero-gravity simulation.

FIG. 2. BASIC ORGANS for detecting gravitational accelerations are the otolith organs. These move in response to gravity or inertia forces. Causing the organs to rotate rapidly about a horizontal axis nullifies their detection abilities.



mediately to fall towards the center of Earth with an acceleration = g ft/sec^2. The value of g depends principally on the distance of the body from the center of Earth, and is equal to at least 60 per cent of the surface value in most orbits attained to date by Earth satellites. An orbiting object is only a special case of free fall, in which the forward (tangential) motion combined with the falling-toward-the-center motion produces a curved path which never intersects the Earth's surface. The weight-effect of gravity is nullified as completely in this case as it is in simple free-fall.

Zero Gravity—True zero gravity is another special case of null gravity. No "weight" would be experienced by a man who was infinitely far removed from all other masses. The absence of a gravitational field would be no different, in this respect, from falling freely in a finite field.

Null-Gravity Simulation—Many of the effects of weightlessness may be obtained simply by immersing a subject in water. If, in addition, the subject is deprived of any visual cues to the true direction of the gravitational vertical, he may find it extremely difficult or even impossible to determine this orientation. Skin divers who have survived such experiences will attest to this. Researchers who have studied these effects in detail have concluded that such a situation is a good first-order approximation to the true null-gravity state.

Water immersion accomplishes the following effects:

(1) The subject is supported by a uniform pressure over each square inch of his body surface. This eliminates one of the most important mechanical cues to the direction of the gravitational vertical—that of localized pressures at support surfaces, such as the soles of the feet or the seat of the pants. When immersed, the subject is unable to detect the fact of being supported, even though the interior portions of the body are supported by the exterior layers.

(2) Muscular effort needed to maintain a posture in the gravitational field is reduced nearly to zero, since each part of the body is supported by the water it displaces. This effect can be enhanced by adjusting the limbs of the body to neutral buoyancy, by use of buoyant bands of material on dense portions of the body and vice versa. This is almost precisely the situation in free-fall; two effects arise from this method of muscle effort reduction:

a. One is sensory. An important cue to the direction and magnitude of the gravitational vertical—tension in the muscles which maintain a posture—is lost.

b. The other is mechanical. Unused muscles tend to atrophy, and the bones to which they are attached tend to deteriorate. This happens during water immersion as it will in space.

(3) Sagging of soft tissues of the body (such as the belly) in a gravitational field is considerably reduced. Stretch sense organs in the tissues supporting such soft areas no longer give information as to the direction and magnitude of the gravitational field.

continued on next page

Buoyancy eliminates pressure-point cues; Rotation nullifies sensors in inner ear

(4) The force of friction between the subject and the walls of the vessel in which he is immersed goes to zero, as it will in space flight. Locomotion within the vessel must be by swimming or by shove-off and inertial coasting. Shove-off will always have a strong component at right angles to the vessel wall, regardless of the direction in which the subject desires to go.

(5) Hydrostatic pressures within the blood-circulatory system are nearly completely compensated by corresponding pressures in the water surrounding the circulatory system. This is good approximation to the situation in free-fall where there are no hydrostatic pressures at all. In either case, distension of the blood vessels by such pressures tends not to occur.

Water immersion, alone, does not accomplish really excellent null-gravity simulation, however. Disorientation does not persist in experienced subjects. After some practice, the subject regains his orientation with respect to the gravitational field, and this orientation is quite effective, although of low angular precision.

This additional sensory cue to gravitational orientation arises in the otolith organs of the inner ears. (Fig. 1.)

These organs are specialized for the detection of lineal accelerations, including the acceleration due to gravity. The photomicrograph in Fig. 2 shows their structure.

The dense otolith particles move in response to gravitational or inertial forces. They bend the brush of hairs on which they are mounted. The resulting distortion of the hair cells activates the nerve fibers surrounding the cells. Thus, information on the direction and magnitude of the net gravitational-inertial field is fed into the central nervous system. In null-gravity situations the net field acting on the otolith particles is zero, and the hairs are undistorted.

A null-gravity simulator nullifies the action of the otolith organs by causing them to rotate rapidly about a horizontal axis (by rotating the entire subject, water, and water tank at the same speed). The viscous damping effect of the gelatinous layer surrounding the brush of hairs prevents the otolith organ from responding fully to any given direction of field before the direction has changed. Like a D. C. voltmeter responding to an A. C. voltage, the otoliths respond less and less fully as the frequency of direction-change becomes greater, until at some frequency the response is so small as to be below the threshold of sensation.

In this way the last major cue to the existence of a gravitational field is taken from the subject. The basic conditions for the establishment of successful null-gravity simulation have therefore been met: (1) Deprive the subject of all usable sensory cues to the existence of a gravitational field, (2) Arrange his environment to duplicate as many as possible of the physiological effects of weightlessness.

The Simulator—The basic idea for null-gravity simulation—immersion plus rotation—was apparently conceived independently in 1958 by three investigators, Muller, Stone, and Schueller. After an extensive biophysical analysis, it was decided to implement the Muller concept in the Human Factors Research Laboratory at Lockheed Georgia Div. The Stone approach is being tested by the NASA Space Task Group, Langley Field, Virginia. An early conception of the Lockheed simulator is shown in Fig. 3. Fig. 4 shows present hardware design.

The dimensions are 5 ft in diam by 9 ft in length. The tank holds

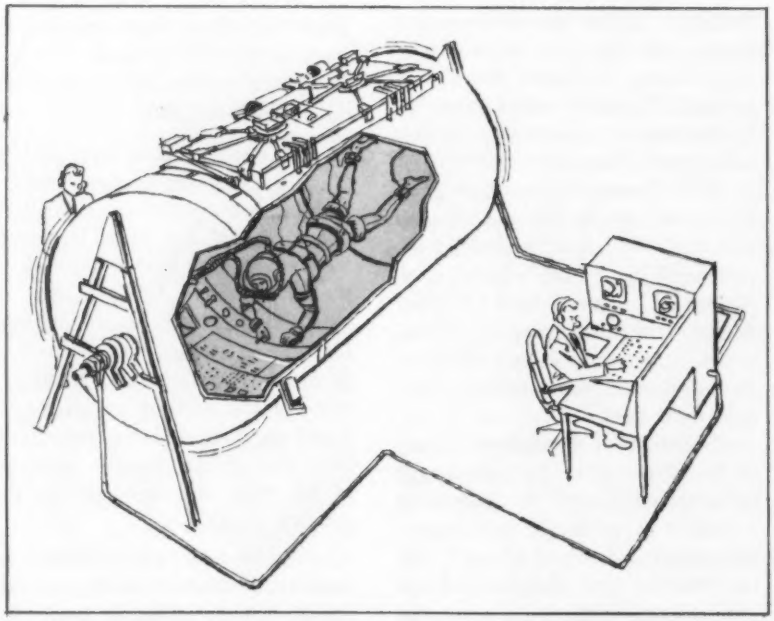


FIG. 3. NULL-GRAVITY SIMULATOR at Lockheed's Georgia Div. uses combined buoyancy and rotational effects to eliminate sensory cues to gravity. Sketch shows only basic concept. Tank rotates at zero to 88 rpm, subject is immersed completely, and tank is controlled from a remote panel.

approximately 1300 gallons of water (11,000 lb). It is driven at controlled speeds in the range of zero to 88 RPM by a 10 HP electric motor acting through a magnetic clutch and reducing gears. The subject is provided with respiration and communications equipment, and with safety gear for rapid removal from the tank in case of emergency. The large entry-exit hatch contains a winch, whose six cables connect, at the shoulders, hips, and legs, to a harness worn by the subject. When reeled in, this equipment holds the subject firmly against the inner face of the hatch. By this means, in conjunction with a spring-driven reel on the opposite side of the tank, the subject may also be positioned at any place within the tank along the diameter. In an emergency, a winch pulls the subject rapidly to the inside of the hatch. Tank and subject are stopped by means of a powerful air brake (although the water continues to rotate), and the hatch is opened. The entire procedure takes from 12 to 15 sec.

The tank is operated from a remote control console which also contains instrumentation for monitoring the mechanical functioning of the simulator and the physiological state of the subject. A closed - circuit television system shows the subject's face at all times, and voice communication is also provided. Extensive precautions, similar to those in use at human centrifuge installations, have been taken to insure subject and operator safety.

The final design shown in Fig. 4 has followed closely the original concepts. The tank runs in self-aligning bearings mounted on A-frame supports. The brake shoe bears on the band of unpainted metal to the left of the tank. At the right is the plumbing arrangement which conducts temperature - selected water into the tank through a standpipe and a rotating joint on the axis of the tank. The standpipe allows the subject to make necessary breathing movements by passing an equivalent volume of water into and out of the tank. Three emergency dump valves near the right end of the tank provide a back-up safety measure. Lamps mounted over twelve small portholes are used to present sequencing visual cues (true or false, as desired) to the subject. Electrical power and communications circuits enter the tank through a slip-ring assembly. Breathing air is supplied from an external source by means of a rotating fitting.

Feasibility Tests—Prior to construction of the simulator, a scale model (1-to-7.5) was built and used to study the hydrodynamics of the tank. The Reynold's numbers obtained were applied to the full-scale design. The scale model was also used to test the concept of otolith organ nullification by spinning. The experimental animal used was the fish.

At rotational speeds above approximately 50 RPM, the fish appeared to lose all cues to the gravitational vertical. Since, under normal circumstances, these cues arise largely in the otolithic system, and since the fish otolith is very similar to that of the human being, it appears justifiable to predict that nullification by spinning will be feasible in the case of human subjects. Studies on human subjects in the full-scale simulator will be necessary to establish the full feasibility of the overall concept of null-gravity simulation.

Prior to embarking on a series of investigations, a set of stringent feasibility studies should be carried out to test the degree to which the simulator can produce satisfactory long term weightlessness conditions. If the simulator performs as expected, it should be the forerunner of many such installations. As the human centrifuge has affected the study of hypergravity states, the null-gravity simulator may make possible detailed earthbound study of the prolonged sub-gravity condition. ◆

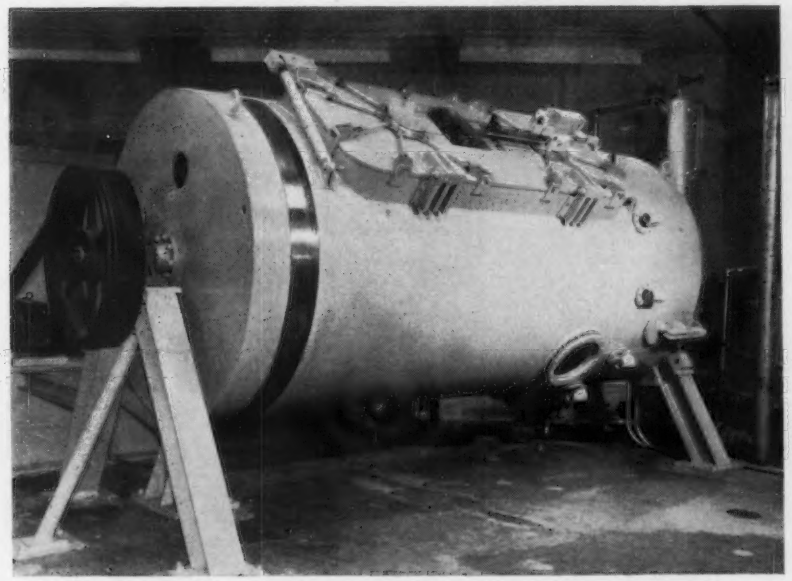


FIG. 4. FINAL DESIGN of Lockheed's simulator is 9 ft long and 5 ft in diam. Tank holds 1300 gallons of water. A 10 HP electric motor is used as the driving force. It operates through a magnetic clutch and reducing gears. Device may become as basic as centrifuge in training and selecting astronauts.

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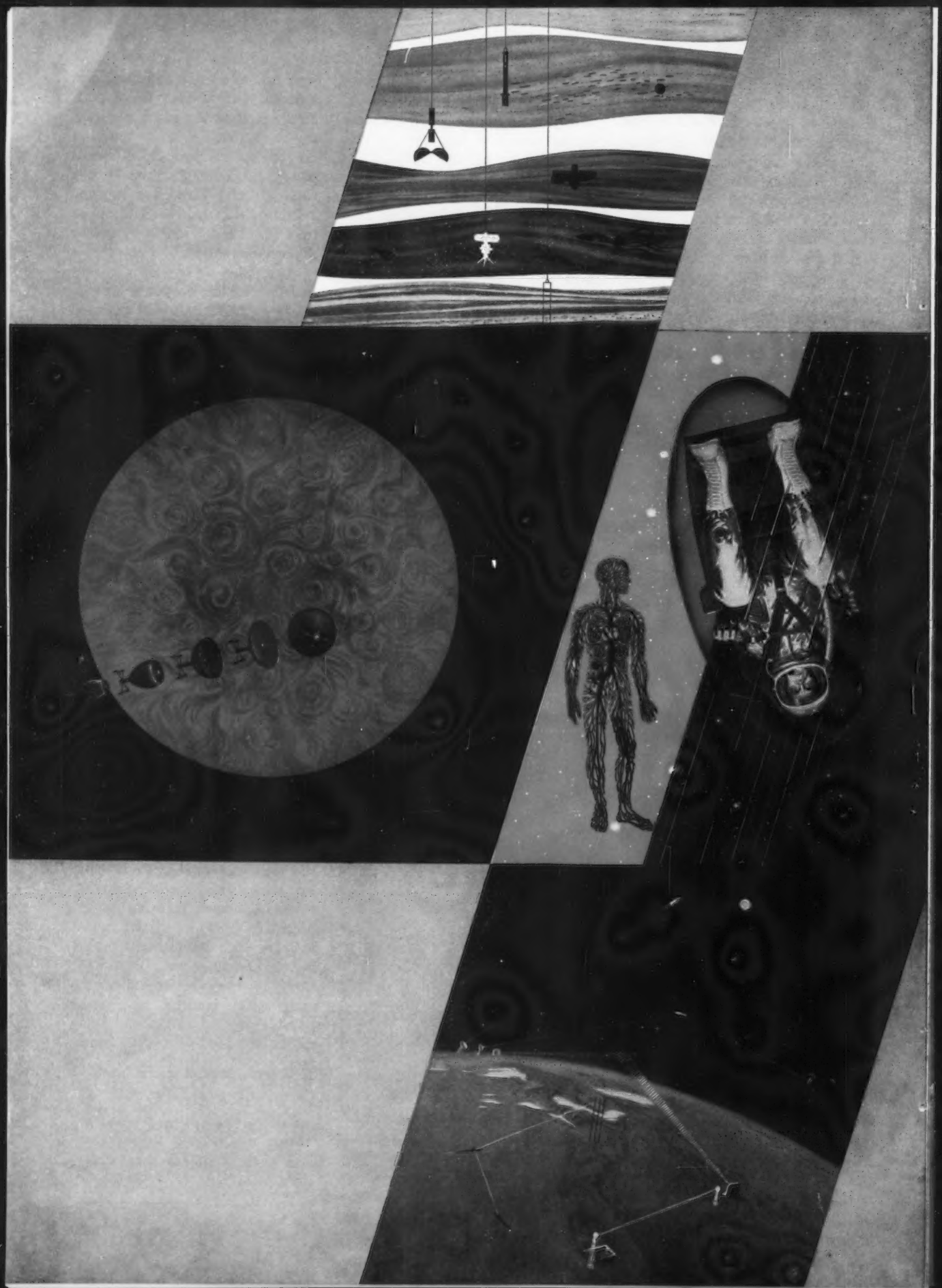
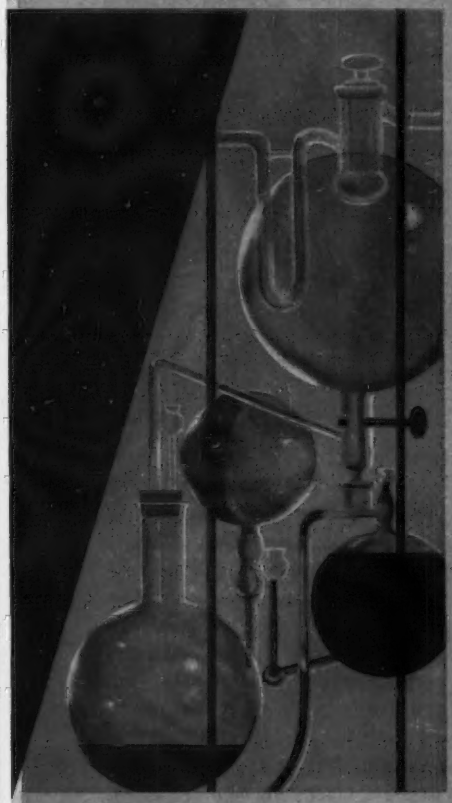


RESEARCH AND DEVELOPMENT AT LOCKHEED



...is setting the pace in space for years ahead

Lockheed Missiles and Space Division's progress transcends even that of an era marked by phenomenal scientific growth. To an important degree, the Division's research and development activities are considered to be the basis of its success.

As systems manager for the Navy POLARIS Missile and the Air Force AGENA Satellite in the DISCOVERER and MIDAS programs, the Division is engaged in extensive research in many diverse engineering and scientific fields. Some highlights of current research and development activities include: Operations research and preliminary design; nuclear and space physics; physical electronics; chemistry; materials; mathematics; engineering mechanics; electronic communications and instrumentation; and computer research and development.

Research is a concept which holds many different meanings to those concerned with science and technology. At Lockheed, a distinction is made between the *nature* of the work and its *objectives*. Consequently, such terms as basic research, applied research, systems or operations analysis, engineering and development are used. A given individual might find that his personal inclination often leads him quite naturally from one type of research to another. Recognition of this desire is reflected in the scope of work conducted in the Research Branch at Lockheed Missiles and Space Division. Principal research activities are: Pure and applied research; advanced design; engineering analysis; electronic prototype development; and machine computation.

Organization is determined by the *technical field* rather than by the *type of research*. For example, a structural dynamicist, as a member of the Structures Department, may, on one occasion, work on future space vehicle configurations, at another time be associated with current projects such as the POLARIS or Satellite programs, or he may be engaged in basic research at the research laboratory. In each case, the individual has the opportunity to maintain as much or as little contact as he wishes with others in his field of interest.

Important staff positions at Lockheed's Research and Development Branch in Palo Alto are available. Those scientists and engineers with experience related to the above areas are invited to write to: Research and Development Staff, Dept. M-25A, 962 West El Camino Real, Sunnyvale, California. U. S. citizenship or existing Department of Defense industrial security clearance is required. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Lockheed / **MISSILES AND SPACE DIVISION**

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Costs soar—schedules lag

by Philip Geddes

The enormity of Atlas and Titan silo construction is overwhelming. Missile site activation is beyond a doubt the biggest construction job ever undertaken in the history of the U. S. In view of the urgency involved, and the concept of concurrency, management problems were inevitable. They came early and they kept getting bigger as time went on. The pressures built up to the point where a blowoff came before a congressional subcommittee.

"Top Level Failure"—Congress too had its moments of pressure. Before the evidence had even been presented, the chairman of the Subcommittee on Military Construction said, ". . . All too long this program has been characterized by failure of top level management to exercise proper control of a complex construction program . . . and . . . This essential program has also been marked by an instability of design, as attested to be numerous and costly change orders unheralded to my knowledge in any construction program. This all adds up to a sloppy job which is costing a great deal more than expected and is apparently destroying any realistic pricings in the coming Minuteman program."

The harsh words in this "prejudgment" did nothing to solve the problems the Committee was to hear about. The contractors' charges against the government are extensive and bitter.

The basis for general complaint seems to be that the contracts do not allow for costs involved over the fixed price bid. This can be best illustrated by hearing what the contractors themselves have to say.

CONTRACTORS STATE THEIR CASE

Mr. Henry C. Boschen, president, Raymond International, Inc., as sponsor in a joint venture with three other large companies on 12 Atlas F sites around Plattsburg AFB, N. Y., testified: "We believe that the Air Force, the Army Engineers who are our clients on this project, and ourselves have been unintentionally trapped in a circumstance that neither of us, nor none of us, have any power to control. The exotic character of the work that is being done on an experimental basis under military and wartime conditions of urgency have removed all of the concepts that surround the construction contract . . . we have found that these holes in the ground have virtually become a bottomless pit and our funds are being poured into them seemingly without end. . . ." These general statements were supported by specifics:

- Progress schedule difficulties outside of the contract provisions forced the contractor to use men and equipment inefficiently to meet deadlines.
- Premium time payment went to men working seven day weeks in which productivity allegedly dropped 30-50 per cent.
- Sub-surface conditions (unexpected water, rock, quicksands, etc.) handicapped excavations because conditions were entirely different to those "contemplated in the contract."

• Modifications to the contract drawings. Two hundred seventy-four of the original 502 contract drawings were revised.

• Joint occupancy of one site by several contractors.

Contract Deviations—Raymond International Inc. feels that in view of these difficulties, outside of the provisions of the original contract, the only way to save the contractor from carrying a huge financial loss (estimated at 100 per cent over the original $24 million bid) is to change to a cost reimbursable contract.

Contract Administration for the Morrison Knudsen Co., working with two joint venture groups on Titan I complexes at Lowry, Colorado, and an Atlas F complex at Altus AFB, Oklahoma, claims contract procedure was hammered as follows:

"We had every reason to believe . . . that the standard Government contract with its history of operations and procedures would function on this ballistic missile program as it always had on other Corps of Engineer projects. Patently this is not the case."

The examples of contract deviation from the accepted were summed up in three parts:

"First, the relationship between the contractor and the contracting officer, developed through the years, no longer exists.

"Secondly, the construction agency is now being directed in its actions by the using agency to a degree never before known and certainly never contemplated by us when we entered into these contracts.

"Thirdly, the concept of equitable and reasonable adjustments in contract costs, contract time, and schedules is and has been completely ignored.

"As a result of these changes in contract procedure, the Government's estimates of the costs of performing modification work are completely unrealistic—as is its refusal to recognize changed conditions." The latter statement seems justified by the facts in Table I.

TABLE I—COST OF CHANGES AT TITAN AND ATLAS SITES

Missile Site and Modification	Preliminary A. & E. Estimate	Preliminary Corps of Engineers Estimate	Contractors Proposal	Final Settlement
Forbes, mod No. 12	$60,000	$200,000	$1,782,312	$1,203,335
Lowry I, mod No. 1	51,011	500,000	7,803,263	4,937,373
Lowry I, mod No. 29	60,000	60,000	1,059,405	1,059,405
Offutt, mod No. 10	None	300,000	1,432,593	750,000
Schilling, mod No. 84	None	235,000	1,572,665	Pending
Walker, mod No. 11	333,960	335,400	3,489,787	Pending
Warren III, mod No. 9	81,000	127,123	492,079	233,968
Lowry II, mod No. 2	252,000	252,000	2,605,687	Pending
Forbes, mod No. 94	None	375,000	2,245,358	Pending
Beale, mod No. 2	−11,314	69,298	145,954	87,700

Changes Upon Changes—Of nine Atlas E sites at Lincoln AFB, Nebraska, Mr. Garland Everist, president of Western Contracting Corporation, said, ". . . I would like to point out the basic difference between the Titan and Atlas bases. . . . Titan bases have three general areas of construction with a period of 2 years to construct, and the Atlas bases have 12 different areas of construction with essentially 13 months to construct—13 to 15 months—so there is in comparison a compression of time and results from any changes that occur are magnified.

"Modifications to date have affected 312 pages of the original 476 pages of specifications, and 1214 new drawings have been issued as compared to the original 355 drawings.

"Modifications have affected 68 per cent of the structural steelwork and increased by 55 per cent the number of field bolts.

"Modifications have increased the weight of the silo crib steel by 36 per cent and the number of special connections per site have increased from 184 to 1506.

"Modifications have affected 77 per cent of the mechanical piping work, with the utility piping system having been modified six times. One critical piece of manufactured electrical control equipment has been modified eight times, the latest being only three weeks prior to contract installation date. The list is almost endless. . . ." Mr. Everist's company is losing money, he projects a $12 million loss at Lincoln.

Not All Bad—But not all the silo contractors slam Uncle Sam. Thomas H. Paul, V. P. of Peter Kiewit Sons' Company, low bidder on the Titan site at Beale, Calif., made these observations about his position and that of his subcontractors. He qualified his remarks by the fact that Titan I work suffered only about half the "changed conditions" of the Atlas F work. "The earthwork, silo excavation, concrete and steel work are just ordinary construction work familiar to our company and our employees, and to the Corps of Engineers personnel with whom we deal. There is no question about their competency in this type of work. We enjoyed a fine relationship with the Corps of Engineers personnel and the Air Force people with whom we came in contact."

THE AIR FORCE CASE

Having heard industry's side of the story it is only fair to hear the Air Force rebuttal. A high ranking Air Force officer close to the project says the Congressional Subcommittee failed to allow the Air Force to present a full case and that "some light would have been shed if the contracting officer had been allowed to question some of the contractors present."

He emphasized that the opinions presented were the worst side of the story from several contractors not necessarily representative of the whole site activation program.

"Why are they complaining? Money is the answer . . . although we cannot tell for sure what they mean by financial loss. Are they losing money or estimated profits?"

Air Force, contractors, and architects tell why hard-sites cost so much and take so long to build

He adds the problems of "poor management" on the contractor's part received little attention in the hearings. Some jobs were constantly in trouble, defective work had to be removed. At some sites the accident rate was unusually high and was proportional to the poor management.

Air Force Surprised—Some of this has been touched on by the Under Secretary of the Air Force, Dr. Joseph V. Charyk, in a letter to the chairman of the hearings. ". . . We were surprised that not a single contractor accepted our offer to discuss his problems, as I suggested in the conclusion of my presentation to your committee."

Flagrant Misrepresentations — "I would like to take just a moment of your time to give you a few specific examples of what we consider a flagrant misrepresentation of facts by contractors before your committee, to illustrate what we have in mind:

(A) One contractor made the statement that his primary difficulties were due to changed site conditions and to the volume of change orders. We recognize, as we have repeatedly stated, the problem of change orders. However, we feel there were many more important reasons for this contractor's problems. The contract was let in early June 1960, in order that they could have full advantage of the construction season. Government representatives, Air Force and Corps of Engineers, who visited the site repeatedly called to the contractor's attention the fact that he was behind schedule and that, based on our experience with other squadrons, unless he made a greater effort he would have trouble. We have incorporated in the contracts certain milestones for each launcher which the contractor must meet. At our last report, this contractor had met his contractual schedule on only 2 of 15 milestones. The Corps of Engineers' efforts to make the contractor meet his construction schedules contained in contractual documents was called expediting and is primarily the basis for his claim.

(B) Another contractor made a presentation of his problems without once mentioning the fact that the Corps of Engineers has called to his attention repeatedly his failures to perform both as construction contractors and as fabricators furnishing equipment. One division of this firm manufactured equipment which is being installed by another division under separate contract. The delay in delivering this equipment on schedule was used as a basis by the contracting division of the firm as reasons for claims. . . .

(C) Another contractor did not have adequate equipment either from the standpoint of quality or quantity to get the job done. This poor management was called to the attention of the contractor very early, and he failed to take remedial action. He also claimed changed conditions, as represented by the soil-borings, and, in this case, the Air Force engaged consultants to evaluate his claims since they were based upon the design and the Army engaged a different group of consultants to evaluate the claim. In both cases, it was found that the specifications were adequate. However, the contractor still maintains he has a legitimate claim of many millions of dollars for those reasons."

Poor Bid Estimates—As an example of poor bidding, an Air Force officer says, "Many firms did not analyze the job properly. On the Titan II at Davis-Monthan the low bid was $27.8 million. The next Titan II contract was McConnell for $30.8 million and the third Titan II was Little Rock for $28.7 million. The contractor winning the third job had bid the Davis-Monthan job for $38 million, nearly $10 million higher than the winning bid. Doesn't it follow that the contractor cut that amount off his third bid just to get the job? The time difference between the contracts was only four weeks. What could he have learned other than that if he did not change his bid he would not get the job?"

Changes Normal?—On changes, the Air Force claims, "There are no significant changes to the silo design. The original overall plans and present, differ little. However, there have been many small changes which harassed the contractor. At Lincoln AFB (Atlas E) there have been 1.4 drawing revisions per original construction drawing. For comparison the Bechtel Corp. submitted some figures on changes considered normal on industrial construction projects. A complex plant with a 29 month completion schedule and target cost of $45.5 million was actually completed in 27 months. Cost savings on this project amounted to 6.6 per cent of the target. During construction, 2920 drawing revisions were issued for a factor of 3.2 changes per original drawing.

"On the part of some contractors there was a basic lack or recognition that they were building an integral part of a weapon system and not a runway or a hanger. The alignment of the steel reinforcing crib in the silo could not be too much out of line, or the silo lift would not operate. Anchor bolts could not be more than the specified percentage out of line. Tolerance was not so strict that it could not be held, but, it was tighter than the majority of contractors had experienced before. The results in some cases speak for themselves (See Table II).

Sloppy Work—"There is other evidence of poor work. At the Lincoln site for example, the entry vestibule to the launch control site settled and has to be rebuilt completely. At another site the top 40 feet of the silo has to be ripped out and rebuilt because poor concrete pouring resulted in honey-

comb voids. These jobs were designed by outstanding companies of architects and engineers chosen by an Air Force/Army board. You may think that the claims are arising out of the initial set of complexes started but this is not true. Lincoln, Walker, and Plattsburg for example were not the first bases started. Being realistic I believe that many of the statements before the committee hearings were being made for the record to support future claims. There is something wrong other than the specs and drawings."

Czar Wont Help—When questioned on the appointment of a missile Czar to see over the complete missile activation program and changes in contracts for the future, Air Force said, "All the people who have a part to play being under one man is no great change. It is not factual that the contractors had to deal with many people for a decision. There always has been a funnel, as in any administrative structure, to the top. Many contractors not making money would like to see the contracts changed from fixed price to cost plus but the congressional committee is still recommending a fixed price advertised bid despite the contractors' pleas. In the Minuteman program we are sticking to a fixed price despite the exception made at the first base at Great Falls, Montana. At Great Falls there have been contractual difficulties. The Government estimate was in the low $50 million area, the lowest bid was $79 million, the high $98 million. The pricing differences in this case are due to the logistics for the contractors supporting effort caused by the area the base covers. The Government relaxed schedules, made some changes with the result that the bids came down into the low $60 million. At Great Falls we have a contract arrangement perfectly acceptable to the Air Force but not to the Congress. It is a fixed price incentive contract. As target price goes up in the course of construction, the contractor begins to lose profit. By the time the ceiling is reached there is no profit left. As he goes below target price he gets more profit up to a fixed limit. Contractors books will be audited. This type contract has some of the benefits of a cost reimbursable arrangement but there is a limit. At Vandenburg we have cost plus fixed fee contracts on both the Titan II and Atlas F launch test facilities. These are the only exceptions to the fixed fee relationship."

TABLE II—OUT-OF-TOLERANCE AND FROZEN IN CONCRETE

Complex	Number of Imbedded Items Discussed	Number Located out of Tolerance
D	249	113
E	249	122
F	249	172
G	249	207
H	249	92
I	249	139
	Total 1494	Total 845

ARCHITECT AND ENGINEER VIEWS

The Air Force and the contractors have stated their cases. There is another party involved in this fiasco—the architect. A principal in a leading company of Architect Engineers responsible for much of the design work in several site programs has this to say:

No Precedents—"The first thing to establish is the enormity of the job. The Hoover Dam cost $46 million and took six years to build. The two Titan squadrons being activated at Lowry are twice as big as the Hoover Dam. No one had ever designed for nuclear blast before. All equipment had to be shock mounted. We find that there were no criteria other than Navy experience with electronic gear on ships. When the site activation program started, even the size of the Atlas and Titan were not firm. The associated contractors to the weapons system manager, such as Rocketdyne and American Machine and Foundry had equipment not even designed, which would have to fit into the silos. As a result of this, there were inevitable changes. Here my sympathy is towards the contractors.

The complaints of the contractors were right to a large extent but they did not understand the job to be done. There were some contractors who were not qualified to do the job."

Old System—On the administration of the silo program the architectural firm Aircraft and Missiles consulted said: "Historically the Corps of Engineers has been a design and construction agency. Most installations in their experience have been the somewhat crude industrial type and they do not have the capability to do advanced work. Air Force and Army installations in the past have been designed and constructed by the Corps, often with civil Architect and Engineer help. In the case of the ICBM's, the Air Force hired their own Architect and Engineers and undertook design of the sites. It was the responsibility of the Corps of Engineers, however, to sign off on the constructability of the designs. Then the administrative system took these plans and the funds provided and turned them over to the Corps of Engineers who were supposed to see that the work was done as expected. It is not surprising that the system did not work."

New System—"This dual system has been replaced by a single integrated team of both Corps of Engineers and Air Force personnel. The old system simply wouldn't work for the highly technical program on a rush basis.

"The Corps of Engineers is handicapped by many laws and regulations composed by Congress over the years. They may have been very good in the past but are not set up for a program of this type with so many unavoidable changes, rush, and high cost. Something like the Manhattan project could never have been achieved if the existing rules and regulations had been applied."

✦

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American Hoist

SAVES SIX HOURS PER WELDMENT

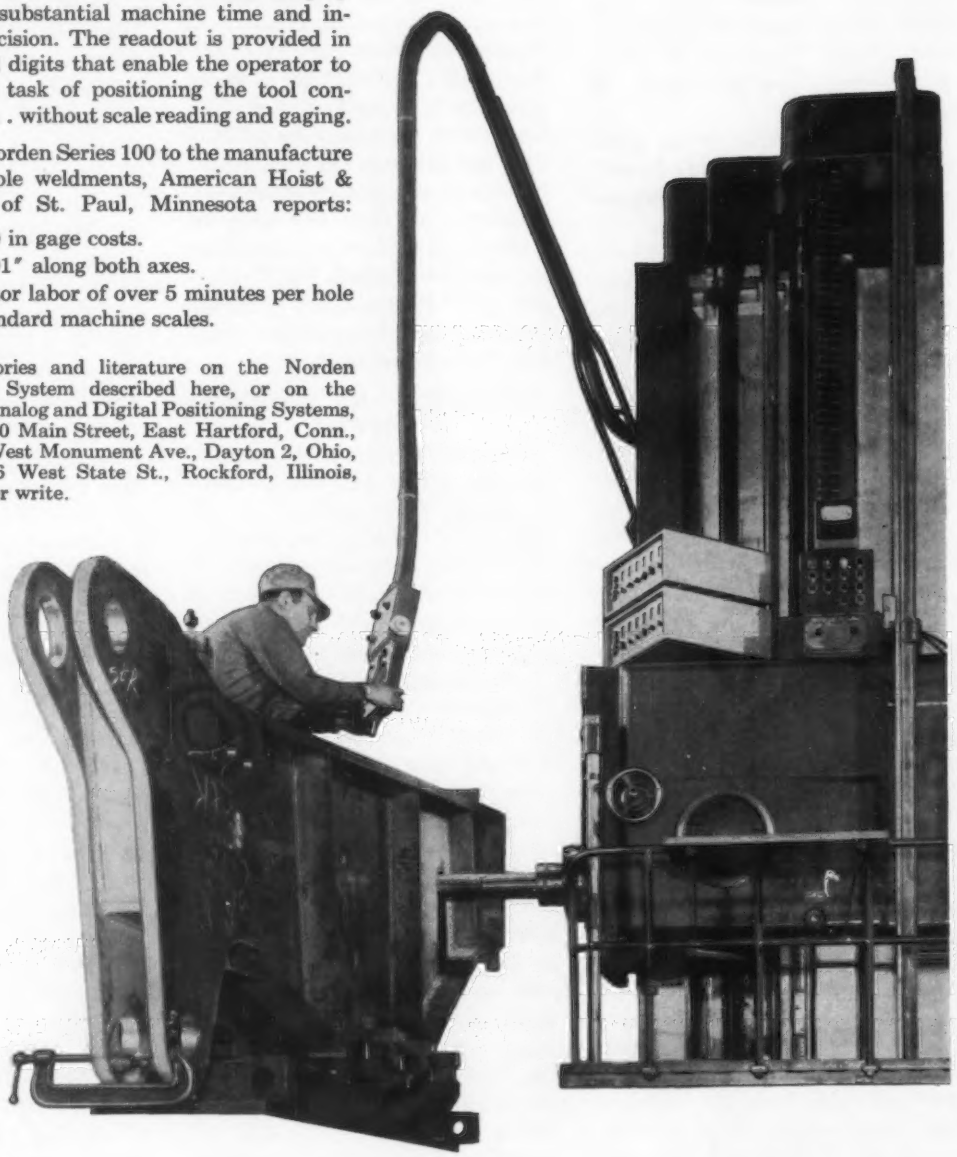
with Norden's Series 100 Modumatic Position Display System

American Hoist's costly, complex weldment structures must be precision bored along both sides of their 16-foot length. Equipping their 7″ Gray Boring Mill with two of Norden's Series 100 Modumatic Display Systems has saved substantial machine time and increased product precision. The readout is provided in six large illuminated digits that enable the operator to accomplish the key task of positioning the tool confidently, smoothly . . . without scale reading and gaging.

In applying the Norden Series 100 to the manufacture of these large 52-hole weldments, American Hoist & Derrick Company of St. Paul, Minnesota reports:

- Savings of $2,000 in gage costs.
- Accuracy to ±.001″ along both axes.
- Savings in operator labor of over 5 minutes per hole location over standard machine scales.

For other case histories and literature on the Norden Modumatic Display System described here, or on the Norden Modumatic Analog and Digital Positioning Systems, contact Norden at 400 Main Street, East Hartford, Conn., JAckson 8-4811; 11 West Monument Ave., Dayton 2, Ohio, BAldwin 8-4481; 206 West State St., Rockford, Illinois, WOodland 5-1891—or write.



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DATA SYSTEMS DEPARTMENT
3501 HARBOR BOULEVARD, COSTA MESA, CALIFORNIA

Aerospace Ground Equipment Directory

Air Force's new label "Aerospace Ground Equipment (AGE)" designates items formerly tagged as Ground Support Equipment (GSE). AGE now includes all equipment used either for operating or maintaining any aerospace item. This directory presents the functional classifications of equipment categories, and major manufacturers of AGE in alphabetical sequence under each category. The directory gives sources where stock items may be procured; it tells where component manufacturers may seek business opportunities. This listing is based on the Air Force Technical Information File of AGE, MIL-HDBK-300 (USAF).

TESTING, MEASURING, & ADJUSTING EQUIP.

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AC SPARK PLUG, GMC — TEST SET COMPUTER
AC SPARK PLUG, GMC — TEST SET, ELECTRICAL CABLE
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AC SPARK PLUG, GMC — TEST SET MOTOR GENERATOR
ADMIRAL CORP, — RADIAC SET
AEROMOTIVE CORP — ECHO BOX
AIRESEARCH — DYNAMOMETER
AIRESEARCH — DYNAMOMETER-MOTOR TEST
AIRTRONICS INTERNATIONAL CORP — MULTIMETER
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B&H INSTRUMENT CO — TESTER, EXHAUST GAS TEMP CIRCUIT
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HUGHES AIRCRAFT CO — TEST SET MECHANICAL VIBRATION
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KEARFOTT CO — FIELD PORTABLE TESTER
KEARFOTT CO — AMPLIFIER TEST PANEL
KELEKET X-RAY CORP — PANEL TEST ELECTRICAL
LAVOIE LABORATORIES — RADIAC SET
LAVOIE LABORATORIES — TEST SET, WAVEMETER
LAVOIE LABORATORIES — FREQUENCY METER
LAVOIE LABORATORIES — ECHO BOX
LAVOIE LABORATORIES — OSCILLOSCOPE
LEAR INC — GENERATOR, SIGNAL
LEAR INC — TEST SET, AMPLIFIER
LEEDS AND NORTHRUP — TEST SET, AUTOMATIC PILOT
LEWYT MANUFACTURING CORP — TESTER, PYROMETER & THERMOCOUPLE
LEWYT MANUFACTURING CORP — SIGNAL GENERATOR
LINK AVIATION — RADAR TEST SET
MAGNAFLUX CORP — TEST SET, FLIGHT SIMULATOR
MAGNAFLUX CORP — FLUORESCENT PENETRANT INSP EQUIP
MAGNAFLUX CORP — MAGNETIC PARTICLE INSTECT EQUIP
MANSFIELD & GREEN — FLUORESCENT PENETRANT
MB MANUFACTURING CO — HYDRAULIC PRESS GAGE
MEASUREMENTS CORP — PORTABLE VIBR PICK UP CALIBRATOR
MERCURY ELECTRONICS — ANTENNA SHIELD
MERIAM INSTRUMENT CO — DIVIDER, VOLTAGE
MICRO BALANCING INC — AIRCRAFT INSTR TEST MANOMETER
MINE SAFETY APPLIANCE CO — MICRO MAMIC DYNAMIC BALANCER
MONUMENT ENGINEERING CO — INDICATOR, COMBUSTIBLE GAS
MUNSTON MFG & SERV CO — TEST SET,SYNCHRO
NETWORK MFG CO — GENERATOR, SIGNAL
NEW LONDON INSTRUMENT CO — DUMMY LOAD, ELECTRICAL
NORTHROP CORP — R F SIGNAL GENERATOR
NORTHROP CORP — ELECTRONIC TIMING GROUP
NORTHROP CORP — GENERATOR PULSE
NORTHROP CORP — RACK AND HOUSING TEMP REGULATOR
NORTHROP CORP — GUIDANCE INSTRUMENT GIMBLE
NORTHROP CORP — CONTROLLER AND SERVO
NORTHROP CORP — FLIGHT CONTROL GYROS
NORTHROP CORP — MAGNETIC COMPASS SYSTEM
NORTHROP CORP — COUPLER, ANALYZER EQUIPMENT
NORTHROP CORP — GYROS AND AZIMUTH SIGNAL AMPLIF
NORTHROP CORP — TEST SET GYRO, PLATFORM
NORTHROP CORP — TEST SET, TAPE STARTER
NORTHROP CORP — TEST SET, LATERAL COMPUTER
NORTHROP CORP — TEST SET, FLT CONT COMP
NORTHROP CORP — TEST SET, D C PWR SUPPLIES
NORTHROP CORP — TEST SET, GUIDANCE
NORTHROP CORP — SIMULATOR, FLIGHT MOTION
NORTHROP CORP — TESTER, FLIGHT CONTROL
NORTHROP CORP — CONSOLE, WARHEAD SYSTEM TEST
NORTHROP CORP — DUPLICATOR TAPE, ARC COMPUTER
NORTHROP CORP — CONSOLE, SWITCHING CONTROL
NORTHROP CORP — CONSOLE, CONTROL, ENGINE START
NORTHROP CORP — PLATFORM TORQUE OVERRIDE TESTER

AEROSPACE GROUND EQUIPMENT DIRECTORY (continued)

NORTHROP CORP	TEST SET, AMPLIFIERS, RUDDER
NORTHROP CORP	TEST SET, ACCEL & VEL SIG
NORTHROP CORP	TEST SET, FLIGHT-CONTROL PLUG IN
NORTHROP CORP	TEST SET, D C PWR SUPPLIES
NORTHROP CORP	TEST SET, SIGNAL DET INTEGR AMPL
NORTHROP CORP	TEST SET, RACK ALARM ASSEMBLY
NORTHROP CORP	TEST SET TEMP REG HOUSING
NORTHROP CORP	TABLE, CALIBRATION
NORTHROP CORP	PHOTOMETER SET
NORTHROP CORP	STAND, AUTOCOLLIMATOR
NORTHROP CORP	STAND, TWELVE-INCH MIRROR
NORTHROP CORP	CONSOLE, POWER TRANSFER
NORTHROP CORP	TEST SET, ELEVON AND POWER LEVER
NORTHROP CORP	TEST SET, ELEVON AMPLIFIER
NORTHROP CORP	TRAILER, FUEL SYS TEST EQUIP
NORTHROP CORP	TEST KIT, BOOSTER EJECTION
NORTHROP CORP	TEST SET, ACCELEROMETER TURRET
NORTHROP CORP	ALIGNMENT DEVICE, OPTICAL TESTER
NORTHROP CORP	TESTER OPTICAL INSTRUMENT
NORTHROP CORP	LAP SET INSTRUMENT
NORTHROP CORP	SUPPORT OPTICAL TESTER
NORTHROP CORP	ALIGNMENT CHECKOUT
NORTHROP CORP	MIRROR, AUTOCOLLIMATOR ALIGNING
NORTHROP CORP	FIXTURE, ANGLE GENERATOR
NORTHROP CORP	COLLIMATOR, TESESCOPE FOCUS
NORTHROP CORP	TABLE, OPTICAL TESTER ALIGNMENT
NORTHROP CORP	LIGHT STANDARD SET, PHOTOMETER
O. E. SZEKELY & ASSOC	GENERATOR, SIGNAL
PACIFIC SCIENTIFIC CO	CABLE TENSIOMETER
PHAOSTRON CO	RELAY TEST SET
PHAOSTRON CO	TEST SET, ELECTRICAL POWER
PHILCO CORP	FREQUENCY METER
POLARAD ELECTRONICS CORP	SPECTRUM ANALYZER
POLARAD ELECTRONICS CORP	SIGNAL GENERATOR
POLYTECHNIC R & D CO	SLOTTED LINE
RADIO FREQUENCY LABORATORIES	FREQUENCY METER
RCA	TEST SET RADAR
RCA	TEST SET, RADIO
RAM METER, INC	TESTER,INVERTER
RAM METER INC	TESTER THERMAL SWITCH
RAYTHEON MANUFACTURING CO	ELECTRICAL DUMMY LOAD
ROCKETDYNE, NAA	RELAY ASSEMBLY
ROCKETDYNE, NAA	TESTER, PNEUMATIC FLOW
ROLLER-SMITH	TEST SET, SYNCHRO
SMALLCROSS MFG CO	CYRSTAL IMPEDANCE
SHAW TELEVISION CORP	RELAY TEST SET
SPERRY GYROSCOPE CO	CALIBRATOR SET, RANGE
SPERRY GYROSCOPE CO	RADAR TEST SET
STAMFORD ELECTRONICS CORP	PULSE GENERATOR SET
STODDART AIRCRAFT RADIO CO	TEST SET, RADIO
STROMBERG-CARLSON	TEST SET, RADIO
SUNDSTRAND MACHINE TOOL CO	STAND, TEST, CONST SPEED DR
SUNDSTRAND AVIATION	PORTABLE FREQUENCY REFERENCE
SWEENEY MANUFACTURING CO	TESTER, TORQUE WRENCH
SYLVANIA PRODUCTS INC ESPEY	TEST SET, RADAR
TAFFET RADIO AND TELEVISION CO	RADIO TEST SET
TEKTRONIX INC	OSCILLOSCOPE
TEKTRONIX, INC	GENERATOR,SIGNAL
TELECTRO INDUSTRIES CORP	FIELD STRENGHT METER
TELETRO INDUSTRIES CORP	TESTER,INVERTER
TELETRO INDUSTRIES CORP	GENERATOR, SIGNAL
TENNEY ENGINEERING, INC	ALTITUDE & TEMP INSTR TEST
THE DAVEN CO	ELECTRONIC MULTIMETER
THE NARDA MANUFACTURING CORP	INDICATOR, STANDING WAVE RATIO
THE SPARKS WITHINGTON CO	FREQUENCY METER
THE VENDO CO	DUMMY LOAD, ELECTRICAL
T.L.G.ELECTRIC CO	FLUX METER
TRACERLAB INC	RADIAC SET
TRANSITRON INC	GENERATOR SIGNAL
UNITED MANUFACTURING CO	STAND,TEST AIRCRAFT GENERATOR
UNITED MANUFACTURING CO	AIRCRAFT GENERATOR TESTER
UNITED MANUFACTURING CO	FIELD PORTABLE TACHOMETER TESTER
UNITED MANUFACTURING CO	PORTABLE LOAD BANK TESTER
UNITED MANUFACTURING CO	PORTABLE ELECTRIC GENERATOR
UTILITY ELECTRONICS CORP	RELAY TEST SET
VIBRATION SPECIALTY CO	VIBRATION TEST STAND ASSEMBLY
VICTOREEN	TEST SET, ELECTRON TUBE
WEINSCHEL ENGINEERING CO	ATTENUATION CALIBRATOR
WESTERN ELECTRIC CO	RELAY TEST SET
WESTERN ELECTRIC CO	DUMMY LOAD, ELECTRICAL
WESTINGHOUSE AIR BRAKE	MOBILE TEST RACK
WESTINGHOUSE ELECTRIC CORP	TEST SET, CORRELATOR
WESTINGHOUSE ELECTRIC CORP	TEST SET GROUP, GENERATOR
WESTINGHOUSE ELECTRIC CORP	TEST-PRESSURE
WESTINGHOUSE ELECTRIC CORP	TEST SET-RECTIFIER ASSEMBLY
WESTINGHOUSE ELECTRIC CORP	TEST SET, PREHEAT, VOLTAGE REG
WESTINGHOUSE ELECTRIC CORP	TEST SET, CYCLING, VOLT REG
WESTINGHOUSE ELECTRIC CORP	TEST SET, RELAY
WESTON INSTRUMENT CO	VOLTMETER
WESTON ELECTRICAL INSTR CORP	AC VOLTMETER
WESTON ELECTRICAL INSTR CORP	FOOT-CANDLE METER
WESTON ELECTRICAL INSTR CORP	FOOT-CANDLE METER
WINSLOW CO	TEST SET ,ELECTRICAL POWER
WAC ENGINEERING CO	CABLE TENSIOMETER

HOISTING, JACKING, LIFTING, & WEIGH. GEAR

AIR LOGISTICS CORP	HOIST MONRAIL YOKE
BALDWIN-LIMA-HAMILTON	KIT, AIRCRAFT WEIGHING
BALDWIN-LIMA-HAMILTON	COMPUTER-PLANNER
BALDWIN-LIMA-HAMILTON	SCALE, AIRCRAFT WEIGHING
BOEING AIRPLANE CO	TRUCK, LIFT, WHEEL CHANGE
BOEING AIRPLANE CO	DOLLY LIFT AIRCRAFT LANDING
COX & STEVENS ELEC SCALES, REVERE	SCALE, AIRCRAFT WIEGHING
DENISON ENGINEERING CO	MANIFOLD SET, HYDRAULIC JACKING
DOUGLAS AIRCRAFT CO	MOUNT, ERECTING LAUNCHING,
DOUGLAS AIRCRAFT CO	DOLLY, MAIN AND NOSE GEAR
GENERAL ELECTRIC CO	CARRIAGE, REENTRY VEHICLE
GENERAL ELECTRIC CO	CRADLE, RE-ENTRY NOSE
GENERAL ELECTRIC CO	CRADLE, RE ENTRY VEHICLE
GENERAL ELECTRIC CO	CARRIAGE RE-ENTRY NOSE
HENRY SPEN AND CO INC	HOISTING APPARATUS, BOMB
LOCKHEED, GEORGIA DIV	TRAILER, LIFT, WHEEL REMOVAL
MEDICO INDUSTRIES INC	JACK, HYDRAULIC, HAND
NEAL MACH AND TOOL CO,	JACK, HYDRAULIC, HAND
NORTHROP CORP	PLATFORM, AIR VEH GUIDANCE ACCESS
NORTHROP CORP	BEAM, HOISTING MISSILE
NORTHROP CORP	ADAPTER, LIFT EXTENSION
NORTHROP CORP	ADAPTER, WING SUPPORT
NORTHROP CORP	ADAPTER, ROCKET HOUSING
NORTHROP CORP	BEAM, WING HOISTING
REGENT JACK MFG CO	JACK, HYDRAULIC, HAND
SMITH NELSON CORP	JACK, HYDRAULIC, HAND
UNITED TRUCK AND EQUIPMENT CO	MANIFOLD SET, HYDRAULIC JACKING
WESTERN GEAR	BAR PRY WHEELED

POWER GENERATING EQUIPMENT

AC SPARK PLUG, GMC	GYRO HEATER POWER SUPPLY
ACCESSORY CONTROLS & EQUIP CO	CART, BOTTLE HIGH PRESSURE AIR
AEROPRODUCTS-ALLISON	STAND, TEST, HYDRAULIC SYSTEM
AIRESEARCH MANUFACTURING CO	TRAILER MOUNTED COMPRESSOR
ALLIS CHALMERS MFG CO	MOTOR GENERATOR
ALLIS CHALMERS MFG CO	GENERATOR SET
AMERICAN ELECTRONICS	MOTOR GENERATOR
BEECH AIRCRAFT CORP,	GENERATOR SET
BOEING AIRPLANE CO	GAS TURBINE PNEUMATIC POWER SET
BOGUE ELECTRIC	MOTOR GENERATOR
CAPITOL ENGINE CO	GENERATOR SET
CATERPILLAR TRACTOR CO	GENERATOR SET
CHICAGO PNEUMATIC TOOL CO	AIR COMPRESSOR
CONSOLIDATED DIESEL ELEC CORP	GENERATOR SET
CONVAIR	MOTOR GENERATOR
CONVAIR	CHARGER BATTERY
CONVAIR-ASTRONAUTICS	PUMPING UNIT, HYDRAULIC
DAVEY COMPRESSOR CO	AIR COMPRESSOR
DETROIT DIESEL ENG DIV, GMC	GENERATOR SET
DOUGLAS AIRCRAFT CO	SWITCHBOARD, POWER
DOUGLAS AIRCRAFT CO	PUMPING UNIT, HYDRAULIC
DOUGLAS AIRCRAFT CO	TEST SET, VALVE ACTUATOR
DOUGLAS AIRCRAFT CO	STAND TEST, HYDRAULIC SYSTEM
DOUGLAS AIRCRAFT CO	VACUUM PUMP, TRAILER MOUNTED
DOUGLAS AIRCRAFT CO	GENERATOR SER, DIESEL
ELEC PROD CO,	MOTOR GENERATOR
ELECTRICAL MACHINERY CO	MOTOR GENERATOR
FAIRBANKS MORSE & CO	GENERATOR SET
FAIRCHILD ENGINE AND AIRCFT CORP	GENERATOR SET
FEDERAL TELEPHONE & RADIO CORP	POWER SUPPLY
FEDERAL TELEPHONE & RADIO CORP	RECTIFIER
FEDERAL TELEPHONE & RADIO CORP	BATTERY CHARGER
GREMCO INC,	MOTOR GENERATOR
MEYER PRODUCTS CO	POWER SUPPLY
MOL-GAR MANUFACTURING CORP	MOTOR GENERATOR
MOL-GAR MANUFACTURING CORP	GENERATOR SET
IDEAL ELECTRIC & MFG CO,	MOTOR GENERATOR
INGERSOL-RAND CO	AIR COMPRESSOR
INTERNATL FERMONT MACHINERY CO	GENERATOR SET
INTERNATIONAL PUMP & MACH WORKS	VACUUM PUMP
JOY MANUFACTURING CO	AIR COMPRESSOR
KOHLER CO	GENERATOR SET
KURZ & ROOT,	MOTOR GENERATOR
LEACH ELECT CO,	MOTOR GENERATOR
LYCOMING DIV, AVCO MFG CORP	GENERATOR SET
MARATHON ELECTRIC MFG CORP	GENERATOR SET
MASTER VIBRATOR CO	GENERATOR SET
MUNSTON MFG & SERVICE INC	POWER SUPPLY
NORTHROP CORP	GUIDANCE SIGNAL SIMUL POWER
NORTHROP CORP	POWER SUPPLY,OPTICAL TESTER
NORTHROP CORP	POWER DISTRIBUTION
NORTHROP CORP	TEST STAND, HYDRAULIC SYSTEM
O. E. SZEKELY & ASSOCIATES	GENERATOR SET
POWER EQUIPMENT CO	POWER SUPPLY
RAPID ELECTRIC CO	RECTIFIER,METALLIC
REPUBLIC AVIATION CORP	CHARGER,BATTERY
SORENSON & CO INC	POWER SUPPLY
STEWART & STEVENSON SERVICE, INC	GENERATOR SET
SUN ELECTRIC CORP	CHARGER BATTERY
THE HOBART BROTHERS CO	GENERATOR SET
THER ELECTRIC & MACHINE WORKS	CHARGER BATTERY
WOLVERINE DIESEL POWER CO	MOTOR GENERATOR
WOLVERINE DIESEL POWER CO	GENERATOR SET
WORTHINGTON CORP	AIR COMPRESSOR

GAS AND/OR LIQUID GENERATING, PRO. SYS.

CONVAIR-ASTRONAUTICS	CONTROL, PRESSURE SYSTEM
CONVAIR-ASTRONAUTICS	PANEL ASSEMBLY, NITROGEN CHARGING
DOUGLAS AIRCRAFT CO	CONTROLLER, HYDRO PNEUMATIC
NORTHROP CORP	SYSTEM INSTALL HIGH-PRESS ENGINE

PROTECT. EQUIP. FOR MATERIAL & PERSONNEL

DOUGLAS AIRCRAFT CO	PROTECTION KIT, TRANSPORT

MAINTEN. SHELTERS, PLATFORMS, STANDS, ETC.

AC SPARK PLUG, GMC	SUPPORT, GYRO PLATFORM
AIR LOGISTICS CORP	STAND ASSEMBLY MAINTENANCE
CONVAIR-ASTRONAUTICS	MAINTENANCE PLATFORM
CRAIG MACHINE CO	SHELTER, ELECTRICAL EQUIPMENT
CRAIG SYSTEMS INC	SHELTER OPERATION
DOUGLAS AIRCRAFT CO	MAINTENANCE PLATFORM
DOUGLAS AIRCRAFT CO	BUILDING, PREFABRICATED
DOUGLAS AIRCRAFT CO	MAINT PLATFORM, GUIDANCE
DOUGLAS AIRCRAFT CO	SHELTER, ENGINE MAINTENANCE
FARM-RITE IMPLEMENT CO	SHELTER, ENGINE MAINTENANCE
FARM-RITE IMPLEMENT CO	MAINTENANCE PLATFORM SET
FEDERAL WINDOWS MFG CO	SHELTER
GENERAL ELECTRIC CO	STAND, MAINTENANCE
GENERAL ELECTRIC CO	STAND, MAINTENANCE, MATING SLING
GENERAL ELECTRIC CO	SHELTER,ELECTRICAL EQUIPMENT
LURIA ENGINEERING CO	SHELTER, ENGINE MAINTENANCE
LURIA ENGINEERING CO	MAINTENANCE PLATFORM SET
NORTHROP CORP	WALKWAY, AFT FUSELAGE
NORTHROP CORP	STAND ASSEMBLY, AFT FUSELAGE WORK
NORTHROP CORP	PLATFORM SIDE
NORTHROP CORP	TABLE, SURFACE CHECKOUT
ROCKETDYNE, NAA	SUPPORT, ROCKET ENGINE
ROCKETDYNE, NAA	STAND, MAINT, ROCKET ENGINE
ROCKETDYNE, NAA	SUPPORT, POWER PACKAGE
ROCKETDYNE, NAA	SUPPORT, THRUST CHAMBER
ROCKETDYNE, NAA	CONTOUR PLATFORM, THRUST SECT

TRANSPORTING & TOWING VEHICLES

AIR LOGISTICS CORP	TRAILER INSTALLATION AND REMOVAL
AIR LOGISTICS CORP	TRAILER ENGINE TRANSPORTATION
BOEING AIRPLANE CO	DOLLY ASSEMBLY, ENGINE
BOEING AIRPLANE CO	BOMB TRAILER, MOBILE LIFT
CONVAIR-ASTRONAUTICS	SEMI-TRAILER, MISSILE
CONVAIR-ASTRONAUTICS	TRAILER, MISSILE BOOSTER
CONVAIR-ASTRONAUTICS	TRAILER, MISSILE HANDLING
CURTIS MANUFACTURING CO	FIFTH WHEEL SUSPENSION SOFT RIDE
DOUGLAS AIRCRAFT CO	SEMITRAILER, MISSILE
DOUGLAS AIRCRAFT CO	PROPELLER SHIPPING TRAILER ASSY
DOUGLAS AIRCRAFT CO	TRAILER, AIRCRAFT ENGINE
DOUGLAS AIRCRAFT CO	BOMB LIFT TRAILER ASSY
FREUHAUF TRAILER CO	BOMB TRAILER
GENERAL ELECTRIC CO	TRAILER, LEFT, RE-ENTRY VEH
LOCKHEED, CALIFORNIA DIV	TRUCK, AIRCRAFT AFT SECTION
LOCKHEED, GEORGIA DIV	TRUCK, ENGINE BUILDUP AND TRANSPORT
NORTHROP CORP	DOLLY, INSTRUMENT FLIGHT POSITION
NORTHROP CORP	SUPPORT COLLIMATOR
NORTHROP CORP	DOLLY ASSY, GUIDANCE EQUIP
PALSGROVE MANUFACTURING CO	TRAILER, ENGINE
REPUBLIC AVIATION CORP	TRAILER, AIRCRAFT ENGINE
ROCKETDYNE, NAA	TRAILER, RAIL TYPE
SOUTH BAY MANUFACTURING CO	TRAILER, MISSILE AND ROCKET
TUBULAR AIRCRAFT PRODUCTS CO	TRAILER, AIRCRAFT ENGINE

AEROSPACE GROUND EQUIPMENT DIRECTORY (concluded)

STORING & SHIPPING CONTAINERS

DOUGLAS AIRCRAFT CO	TANK, STORAGE, HI-PRESS GAS
DOUGLAS AIRCRAFT CO	SEMITRAILER, COMPRESSED GAS
DOUGLAS AIRCRAFT CO	STORAGE, LIQUID OXYGEN
DOUGLAS AIRCRAFT CO	TANK, STORAGE, FUEL

AIR CONDITIONING SYSTEMS

AIRESEARCH MANUFACTURING CO	HEATER, PORTABLE GROUND
AIRTEMP CONSTR DIV, CHRYSLER	AIR CONDITIONER
AMERICAN AIR FILTER CO	HEATER, PORTABLE GROUND
AMERICAN ELECTRONIC INC	AIR CONDITIONER
BLOWERS INC	BLOWER, EXHAUST
C. G. HOKANSON CO INC	AIR CONDITIONER
DAYTON AIRCRAFT CO	HEATER, DUCT TYPE, PORTABLE
DEFENSE PROD DIV, AMER AIR FLTR	HEATER
DOUGLAS AIRCRAFT CO	AIR CONDITIONER, TRAILER MOUNTED
DOUGLAS AIRCRAFT CO	OVEN, THERMAL DRYING, ELECTRIC
GREER HYDRAULICS INC,	BLOWER
HERMAN NELSON CORP	HEATER, PORTABLE UTILITY
HERMAN NELSON CORP	HEATER, ENGINE & SHELTER
HERMAN NELSON CORP	SELF-POWERED PORTABLE VENTILATOR
KECO INDUSTRIES INC	AIR CONDITIONER
MCGRAW ELECTRIC CO	AIR CONDITIONER, ELECTRONIC EQUIP
NORTHROP CORP	CONDITIONER, PREFLIGHT GUIDANCE
NORTHROP CORP	REACTIVATOR, DESICCANT
NORTHROP CORP	TEST STAND, CO, INJECTION SYS
NORTHROP CORP	COOLER, MOBILE, GUIDANCE SYS
O. E. SZEKELY & ASSOCIATES	BLOWER
RECONY CORP	AIR CONDITIONER
STEWART WARNER CORP,	HEATER, DUCT TYPE, PORTABLE
SURFACE COMBUSTION CORP	HEATER, ENGINE & SHELTER
THE READY POWER CO	AIR CONDITIONER
TROPIC-AIRE CORP	AIR CONDITIONER

CLEANING, DE-ICING & DECONTAMINATING EQUIP.

AEROIL PRODUCTS CO	SPRAYING UNIT, CLEANING TRAILER
BOEING AIRPLANE CO	FUEL CELL GROUND SERVICING
CONSOLIDATED MACHINE CORP	STILL, ELECTRIC WATER
D. C. COOPER CO	DEGREASER ASSEMBLY
DOUGLAS AIRCRAFT CO	DEGREASER
HENRY SPEN & CO	SPRAY OUTFIT
JESSE W. EAKINS CO	CLEAN&PURG EQUIP, SOLVENT SPRAY
PITMAN MANUFACTURING CO	SPRAY OUTFIT, CLEANING

FUEL SYSTEM SERVICING EQUIPMENT

BOWSER, INC	VEHICLE, FILTER SEPARATOR
BOWSER INC	TANK & PUMP UNIT, JET-OIL SERVICING
DOUGLAS AIRCRAFT CO	TANK, STORAGE, DIESEL, FUEL
DOUGLAS AIRCRAFT CO	FILTER UNIT, FUEL
HENRY SPEN & CO,	TRAILER, FUEL SERVICING
NORTHROP CORP	TEST SET, FUEL CONTROL
NORTHROP CORP	TRAILER, FUELING ADAPTER
NORTHROP CORP	TRAILER, FUEL SYSTEM SUPPORT
PARAMOUNT PRODUCTS	TRAILER, FUEL SERVICING
ROCKETDYNE, NAA	SERVICE UNIT, LUBRICATING PURGING

SERVICING EQUIP. FOR AIRCRAFT SYSTEM

ARNOLT MANUFACTURING CO	TESTER PRESSURIZED CABIN
CONVAIR, GENERAL DYNAMICS	TOOL ASSEMBLY-BRAZING
DOUGLAS AIRCRAFT CO	CHARGER, BATTERY
GENERAL ELECTRIC CO	PURGER, RE-ENTRY VEHICLE
GREER HYDRAULICS, INC	TESTER PRESSURIZED CABIN
NORTHROP CORP	MONITOR SET, PRESSURE
REPUBLIC AVIATION CORP	TESTER, BATTERY, SILVER ZINC
ROCKETDYNE, NAA	SERVICE KIT, ENGINE CHECKOUT
SPRAGUE ENGINEERING & SALES CO	TESTER, PRESSURIZED AIRCRAFT
SUN ELECTRIC CO	BATTERY, STARTER TESTER

LAUNCHING, LANDING & SECURING EQUIP.

ACME PRECISION PRODUCTS INC	BARRIER, RUNWAY OVERRUN
CONVAIR-ASTRONAUTICS	ERECTION MECHANISM, BOOM
CONVAIR-ASTRONAUTICS	LAUNCHER, MISSILE
NORTHROP CORP	COMPUTER SET, DATA SELECTION
NORTHROP CORP	TEST SET, AZIMUTH REFERENCE
NORTHROP CORP	LAUNCHER ASSEMBLY

LIGHTING, SIGNALING & COMMUNICATING DEVICES

AUDIO EQUIPMENT CO	PUBLIC ADDRESS SET
AUTOMATIC ELECTRIC	REPEATER, TELEPHONE
BARKER AND WILLIAMSON INC	CONTROL, FREQUENCY SHIFT
BARKER AND WILLIAMSON INC	CONVERTER, FREQ. SHIFT
BRIGHT RADIO LABS INC	INTERCOM SET
BRUSH DEVELOPMENT CO	RECORDER REPRODUCER
COLLINS RADIO CO	RECEIVER
CONNECTICUT TELEPHONE & ELEC CO	TELEPHONE CONNECTING STATION
CONNECTICUT TELEPHONE & ELEC CO	SWITCHBOARD
CONNECTICUT TELEPHONE & ELEC CO	SWITCHBOARD, TELEGRAPH
CONNECTICUT TELEPHONE & ELEC CO	SWITCHBOARD, TELEPHONEMANUAL
CONTROL SPECIALITY CORP	TABLE, TELETYPEWRITER
CONTROL SPECIALITY CORP	CONTROL POWER SUPPLY GROUP
CONTROL SPECIALITY CORP	CONTROL TRANSMITTER TELETYPE
CRAIG SYSTEMS INC	RADIO TELETYPEWRITER
CRAIG SYSTEMS INC	TELETYPEWRITER SET
CRAIG SYSTEMS INC	CENTRAL OFFICE TELETYPEWRITER
CROUSE HINDS CO	SEARCHLIGHT
CROUSE HINDS CO	CHAMBER, CABLE TERMINAL
ELECTRIC MOTOR & SPECIALTY CO	REPEATER SET, TELEPHONE
FEDERAL TELEPHONE AND RADIO CO	TERMINAL, TELEGRAPH
FEDERAL RADIO AND TELEVISION CO	AMPLIFIER AUDIO FREQUENCY
GENERAL DEVELOPMENT CORP	REPEATER, TELEPHONE
HOFFMAN RADIO CORP	CONVERTER
INSULINE CORP OF AMERICA	SWITCHBOARD
JACOBSON MFG CO,	REPEATER SET, TELEPHONE
KELLOGG SWITCHBOARD & SUPPLY CO	MAIN DISTRIBUTING FRAME, TELEPHONE
KELLOGG SWITCHBOARD & SUPPLY CO	TELEPHONE CONNECTING STATION
KELLOGG SWITCHBOARD & SUPPLY CO	SWITCHBOARD, TELEPHONE
KELLOGG SWITCHBOARD & SUPPLY CO	SIGNAL ASSEMBLY, SWITCHBOARD
KLEINSCHMIDT LABORATORIES, INC	TELETYPEWRITER SET
KLEINSCHMIDT LABORATORIES, INC	TELETYPEWRITER PERFORATOR
KLEINSCHMIDT LABORATORIES, INC	DISTRIBUTOR TRANSMITTER TELETYPE
LORAIN PRODUCTS CORP	RINGER, TELEPHONE
MARK SIMPSON MFG CO	PUBLIC ADDRESS SET
NORTH ELECTRIC MANUFACTURING CO	SWITCHBOARD, TELEPHONE
NORTHERN RADIO CO	CARRIER RACK TELEGRAPH
NORTHERN RADIO CO	CONVERTER, FREQUENCY SHIFT
OLYMPIC RADIO AND TELEVISION INC	RECORDER REPRODUCER
PEIRCE WIRE RECORDER CORP	RECORDER REPRODUCER
PRESTO RECORDING CO	AMPLIFIER AUDIO FREQUENCY
PRESTO RECORDING CO	RECORDER REPRODUCER
RADIO FREQUENCY LABORATORIES INC	TERMINAL TELEGRAPH
RADIO FREQUENCY LABORATORIES INC	CONVERTER, FREQUENCY SHIFT
SILTRONIC CO	AMPLIFIER, AUDIO FREQUENCY
STELMA INC	REPEATER, TELEGRAPH
STROMBERG CARLSON	CONVERTER
STROMBERG CARLSON	LINE RELAY
STROMBERG CARLSON	TERMINAL, TELEGRAPH -TELEPHONE
STROMBERG CARLSON	TELEPHONE CIRCUIT, TRUNK RELAY
STROMBERG CARLSON	CENTRAL OFFICE SET
STROMBERG CARLSON	TELEPHONE CENTRAL OFFICE GROUP
STROMBERG CARLSON	SWITCHBOARD, POWER
TECHNICAL MATERIAL CORP	FILTER, DISTORTION
TELECTRO INDUSTRIES	RECORDER REPRODUCER
TELETYPE CORP	PRINTER PROJECTOR
TELETYPE CORP	REPERFORATOR
TELETYPE CORP	DISTRIBUTOR TRANSMITTER
TELETYPE CORP	PERFORATOR
TELETYPE CORP	TELETYPEWRITER SET
TIMES FACSIMILE CORP	KEYER ADAPTER
TIMES FACSIMILE CORP	FACSIMILE SET
TIMES FACSIMILE CORP	FACSIMILE RECORDER
TIMES FACSIMILE CORP	FREQUENCY SHIFT CONVERTER
TIMES FACSIMILE CORP,	CONVERTER, FREQ. SHIFT
WESTERN ELECTRIC CO	RECEIVER GROUP
WESTERN ELECTRIC CO	REPEATER, TELEGRAPH
WESTERN ELECTRIC CO	TERMINAL, TELEGRAPH
WESTERN ELECTRIC CO	REGULATOR, AUDIO LEVEL
WESTERN ELECTRIC CO	RADIO TELETYPE TERMINAL EQUIPMENT
WESTERN ELECTRIC CO	TERMINAL, TELEPHONE
WESTERN ELECTRIC CO	SWITCHBOARD, TELEPHONE
WESTERN ELECTRIC CO	TELEPHONE TERMINAL
WESTERN ELECTRIC CO	CARRIER TERMINAL
WESTERN ELECTRIC CO,	TELEPHONE CONNECTING STATION
WESTERN ELECTRIC CO	REPEATER, TELEPHONE
WESTERN ELECTRIC CO,	REPEATER SET, TELEPHONE
WESTERN ELECTRIC CO	TERMINAL
WESTERN ELECTRIC CO	RINGING SET
WESTERN ELECTRIC CO	CARRIER TERMINAL
WESTERN ELECTRIC CO	CONVERTER SET
WESTERN UNION TELEGRAPH CO	MULTIPLEXER
WESTERN UNION TELEGRAPH CO	DEMULTIPLEXER
WILCOX-GAY CORP	CONVERTER, FREQ. SHIFT

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MACK TRUCKS INC	TRUCK,FIRE FIGHTING,AIRCRAFT
MARMON-HERRINGTON CO	TRUCK FIRE FIGHTING,AIRCRAFT

MISSILE CHECKOUT & TEST EQUIPMENT

AMERICAN BOSCH ARMA	PRISM AZIMUTH REFERENCE
AMERICAN BOSCH ARMA	STAND, MAINTENANCE GUIDANCE
AMERICAN BOSCH ARMA	TEST SET, IGS SIGNAL COND
CONVAIR-ASTRONAUTICS	CONSOLE, TELEVISION CONTROL
CONVAIR-ASTRONAUTICS	RECORDER GROUP
CONVAIR-ASTRONAUTICS	AUTOPILOT GROUP, GROUND CONTROL
CONVAIR-ASTRONAUTICS	VIEWER, TELEVISION
CONVAIR-ASTRONAUTICS	TELEVISION CONTROL GROUP
CONVAIR-ASTRONAUTICS	TEST SET, PROPELLANT UTILIZATION
CONVAIR-ASTRONAUTICS	TEST SET, PNEUMATIC
CONVAIR-ASTRONAUTICS	DISTRIBUTION, UNIT, CABLE
DOUGLAS AIRCRAFT CO	CHECKOUT STATION, MISSILE
DOUGLAS AIRCRAFT CO	LAUNCHING CONTROL GROUP
DOUGLAS AIRCRAFT CO	MISSILE LAUNCH SIMULATOR
DOUGLAS AIRCRAFT CO	MISSILE LAUNCHING COUNTDOWN GROUP
GENERAL ELECTRIC CO	SIMULATOR, RANGE
GENERAL ELECTRIC CO	TEST SET, RATE ANTENNA BORESIGHT
GENERAL ELECTRIC CO	TEST SET, RE-ENTRY VEHICLE
HUGHES AIRCRAFT CO	TEST SET, GUIDANCE
HUGHES AIRCRAFT CO	TEST SET, CLUTCH CHARACTERISTICS
HUGHES AIRCRAFT CO	TEST SET, HYDR POWER
HUGHES AIRCRAFT CO	TEST SET ASSURANCE
HUGHES AIRCRAFT CO	TEST SET, ERROR CHANNEL CHASSIS
HUGHES AIRCRAFT CO	TEST SET, FINAL
HUGHES AIRCRAFT CO	TEST SET FRICTION & ATTITUDE
HUGHES AIRCRAFT CO	TEST SET, I. F. AMPLIFIER
HUGHES AIRCRAFT CO	TEST SET CONTINUITY
HUGHES AIRCRAFT CO	TEST SET, R.F.
HUGHES AIRCRAFT CO	TEST SET DRIVER ADJUST GUIDANCE
HUGHES AIRCRAFT CO	TEST SET, SCANNER GUIDANCE
HUGHES AIRCRAFT CO	TEST SET, RETICLE SELECT
HUGHES AIRCRAFT CO	TEST SET, CARRIER AMPLIFIER
HUGHES AIRCRAFT CO	TEST SET PULSE GENERATOR
HUGHES AIRCRAFT CO	TEST SET, ELECTRICAL POWER
HUGHES AIRCRAFT CO	TEST SET, CLOSED LOOP FRICTION
HUGHES AIRCRAFT CO	TEST SET, VANE RUN IN
HUGHES AIRCRAFT CO	TEST SET, MOTOR DYNAMIC BALANCE
HUGHES AIRCRAFT CO	TEST SET, CELL GUIDANCE UNIT
HUGHES AIRCRAFT CO	TEST SET, FOCUS & ALIGNMENT
HUGHES AIRCRAFT CO	CALIBRATOR GROUP
HUGHES AIRCRAFT CO	TEST SET, RATE SENSOR CONVERTER
HUGHES AIRCRAFT CO	TEST SET RATE SENSOR CALIBRATION
HUGHES AIRCRAFT CO	TEST SET LEAKAGE
HUGHES AIRCRAFT CO	TEST SET, FINAL SERVOPOSITIONER
MCDONNELL AIRCRAFT CORP	TRAILER, FLIGHT MONITORING
MCDONNELL AIRCRAFT CORP	TRAILER, SPARE PARTS
MCDONNELL AIRCRAFT CORP	TRAILER, CAPSULE CHECKOUT
MCDONNELL AIRCRAFT CORP	TRAILER TELEMETRY
NORTHROP CORP	TEST,SET,LOAD BANK
NORTHROP CORP	TEST SET, FLIGHT CONTROL COMPUTER
NORTHROP CORP	GUIDANCE FUNCTION COMPUTER
NORTHROP CORP	STAND, INSTRUMENT BALANCING
NORTHROP CORP	INDICATOR SET, ELEVON POSITION
NORTHROP CORP	SIMULATOR GUIDANCE SIGNAL
ROCKETDYNE, NAA	PROGRAMMER, ENGINE CHECKOUT
ROCKETDYNE, NAA	STAND, TEST, ELECTR PNEU HYDR
ROCKETDYNE, NAA	PLATES AND PLUGS KIT, ENGINE
ROCKETDYNE, NAA	STAND, TEST, ELECTR-PNEU-HYDR
ROCKETDYNE, NAA	PUMPING UNIT HYDRAULIC
ROCKETDYNE, NAA	ADAPTER SET

ENGINE CHECKOUT, SPECIALIZED EQUIPMENT

CONVAIR-ASTRONAUTICS	FIXTURE, THRUST CHAMBER ALIGN
CONVAIR-ASTRONAUTICS	CONTROL, PURGING, ROCKET ENGINE
LOCKHEED	MOBILE TEST STAND
ROCKETDYNE, NAA	SIMULATOR, ENGINE OPERATION

TRAINING EQUIPMENT

LINK AVIATION	TRAINER, FLIGHT SIMULATOR
NORTHROP CORP	SIMULATOR SET,GUIDANCE SIGNAL

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New Face For Man-In-Space

Optimism reigns after first manned-Mercury shot, Apollo could reap long-range benefits of new attitude; Shepard-shot entitles von Braun to say "I told you so"

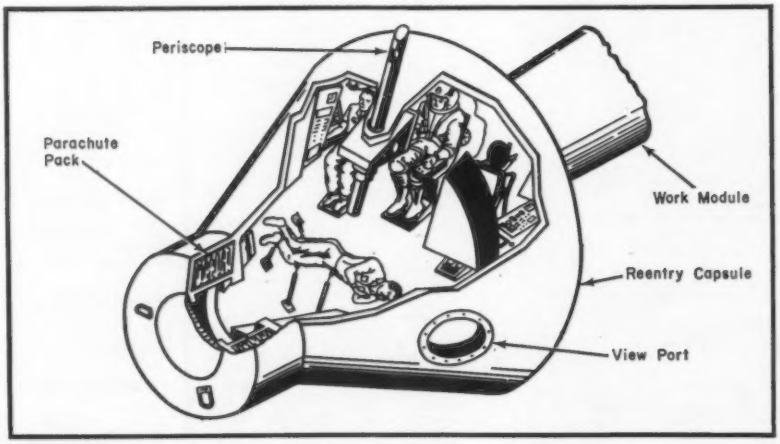
A short, fifteen minute ride seems to have turned the tide from pessimism to optimism in our man-in-space program.

Future space pilots may liken Freedom Seven's up-and-down flight to the touch-and-go landing practice in today's pilot curriculum. Two critical phases of the flight were tested, takeoff and landing. But we never left the landing pattern.

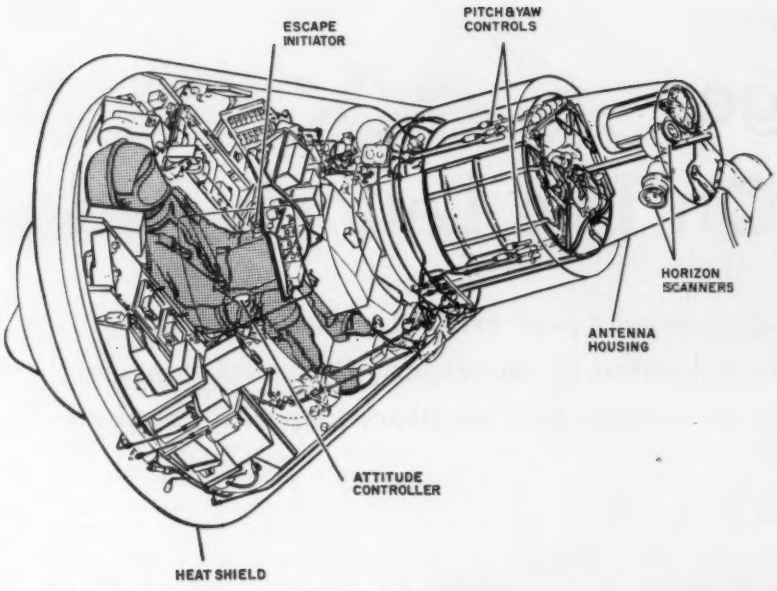
What did it all prove? The scientific gains may be nebulous. But one thing is clear as crystal. The flight proved Dr. Werhner von Braun was right again. He advocated such a flight three years ago. He was voted down. He also advocated our first satellite shot long before the Vanguard we would all like to forget. But he was voted down then too. The von Braun theory is that space dominance is so important for world prestige that some flights have to be made for purely psychological reasons. Each time von Braun has been vetoed it has been by non-technical men who purportedly understand management and political problems better than the "technical minds." Can lightning strike again. It can and it probably will.

What's Next—The next significant man-in-space effort will come with the orbital Mercury shot. Hopefully this will occur this year. If it is successful the role of NASA as the agency to run our space efforts will be practically assured. NASA's next big plans are for the Saturn-boosted Apollo. This three-man space lab and moon orbiter clings to the ballistic (or semi-ballistic) approach to reentry. During the flight the costly booster falls in the ocean and before the reentry, the space ship comes apart so that only a small capsule reenters and is reclaimed. Right or wrong, this is the way we are going with Apollo, the man-in-space vehicle losely targeted for 1966-67.

Economic Fallacies—Indecision and lack of direction in our space program can be traced to the money outlay required. The President's Scientific Advisory Committee magically produced a requirement of $40 billion to put an expedition on the Moon. Numbers like this have caused many to hesitate before leaping.



REPUBLIC DESIGN reflects original NASA thinking that Apollo should draw heavily from Mercury's technical inputs. Republic is one of several companies proceeding with own money to stay in the race for Apollo funds. NASA evaluated GE, Convair, Martin Co., funded design studies in mid-May.



MAN IN A CAN impression of Mercury astronauts and their capsule has long plagued this program. Trick title came from early talk, mostly by engineers that everything in the Mercury capsule would be automatic. There are actually 57 switches, 34 mechanical levers, and 31 fuses over which astronaut has some control. Astronauts themselves are a driving force to get more and more manual control into the systems. Their influence is already being felt in the design concepts of Project Apollo.

In January 1960 when Congress was looking into spending $100 million on the Saturn program von Braun had this to say: ". . . if the value of American stock in the eyes of the world drops a billion dollars because the Russians publish a photograph of the far side of the Moon, and if we could have done it for one-tenth of that amount, it would have been a good investment to have done it ahead of the Russians."

The same analysis holds today.

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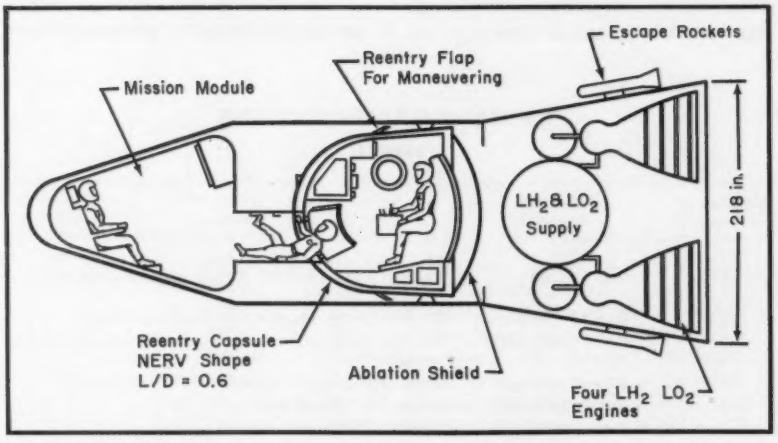
APOLLO STAR TRACKER is outgrowth of studies conducted by Martin Co. Guidance will be a major problem in 3-man Earth and Moon orbiter. Star Field Tracker reads star patterns, establishes a pointing axis in space, and orients space vehicle in flight.



GENERAL ELECTRIC DESIGN for Apollo would incorporate mission module and reentry capsule. Both compartments would have "shirt-sleeve environment" in normal operation. Overall vehicle would have 18-ft diam skirt to mate with Saturn. Nerv-shaped reentry capsule would weigh about 1500 lb.

AGE Gauges On The Launch Pad

Bourdon-tube dial reading gauges play critical prelaunch role; Missile systems must be activated by Aerospace Ground Equipment; High-pressure hydraulic-pneumatic flow monitored by dial gauges

by W. L. Buffenmyer, Chief Application Engineer,
U.S. Gauge Div., American Machine Metals Inc.

Nearly every step in preparing a missile for launching is monitored by dial indicating pressure gauges. This article tells how gauges are being used in leading missile systems. It will help guide engineers designing and specifying components for current and future Aerospace Ground Equipment (AGE). A check list gives tips on specifying.

Before a missile is launched propellants must be handled, ground equipment pretested, and flight systems checked out. Monitoring many of the critical procedures are bourdon-tube dial indicating pressure gauges. Technicians scanning these gauges get a clear picture of the missile's readiness.

Generally, dial indicating pressure gauges are panel mounted, often in fixed console units, similar to that shown in Fig. 1. Sometimes they are mounted on units in service trailers, as in Fig. 2. They may also be mounted directly on pressure lines delivering liquids and gases to the missile, as in Fig. 3.

Gauge requirements in AGE— While gauge requirements will vary with individual missile support needs, some generalizations can be made. Pressure ranges vary from zero to 10,000 psi, with accuracies up to ½ percent of full scale. Depending upon service conditions gauges may be temperature compensated. Some will require adjustable pointers and means to restore the accuracy of the gauge under rugged service conditions. When panel mounted, gauges are often of the recess type with tapped holes to permit removal from the front of the panel. When subjected to continuous surges and extreme fluctuations gauges are protected by pulsation dampeners.

Jupiter Hydro-pneumatics — A hydro-pneumatic trailer services the Army-developed Jupiter missile. It provides a source of clean filtered hydraulic fluid under pressure. Thus, hydraulically-operated missile functions can be energized without using the vehicle's hydraulic pump.

Two gauges indicate supply and return pressures. Their ranges are 0 to 5,000 psi and 0 to 60 psi respectively. Primarily, the gauges monitor proper system function during checkout of the missile's hydraulic system.

The pneumatic portion of the Jupiter's service trailer provides high pressure storage and controls distribution of gaseous nitrogen for pneumatically-operated missile and other ground equipment functions. In this service, six pressure gauges are used to monitor pneumatic sys-

JUPITER PNEUMATIC GAUGES

Table I

Number of Gauges	Pressure Range	Service
1	0 to 10,000 psi	Monitor 5,000 psi inlet supply for charging missile's storage bottles
1	0 to 10,000 psi	Monitor pneumatic storage bottle pressure
1	0 to 300 psi	Monitor pressures to pneumatically-operated control valve
1	0 to 10,000 psi	Monitor high pressure outlet of control valve
1	0 to 5000 psi	Monitor 3,000 psi service
1	0 to 2000 psi	Monitor 750 psi service

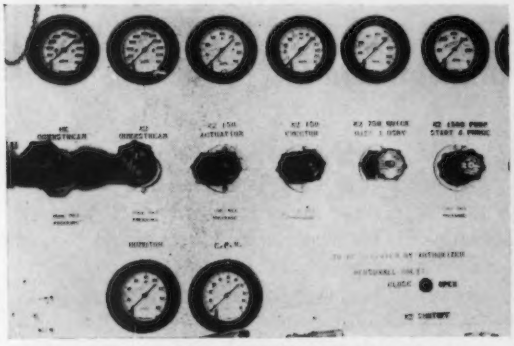


FIG. 1. AT MARTIN-DENVER, where Titan undergoes complete ground check including static firing, dial pressure gauges are found in heart of control center. Panel shown is for main control of N_2 and H_2.

tem function during checkout. (See TABLE I).

Redstone Trailer — Gauges in the pneumatic servicing trailer of the Army's Redstone missile perform a similar function to those used with the Jupiter. Seven gauges are used: five in the range of 0 to 10,000 psi; one, 0 to 5,000 psi; and one, 0 to 1,000 psi.

Functionally, these gauges are used only to monitor operation during checkout of the weapon's system or sub-system. During final countdown, they are not accessible. Feedback required to continue the countdown is supplied by pressure switches that provide automatic sequencing or an O.K. signal to the launch control.

During checkout, gauges are monitored to check manual sequencing, functioning of associated pressure switches and also to trouble shoot malfunctions. These gauges must have accuracies of one percent of mid-range and 1½ percent of full scale.

The leak test console, in the pneumatic-shop-van servicing the Redstone, checks out the missile's pneumatic system and sub-systems. The console is connected pneumatically and electrically to the missile for a series of pressure and leak checks. (See TABLE II).

The accuracy requirements for the gauges on the leak test console are the same as for those in the servicing trailer except that the three 0-3 to 500 psi gauges require accuracies of 0.5 percent of full scale.

Aerobee 150A — At NASA's Wallops Island launch site, gauges used on the propellant servicing and high pressure helium systems of the Aerobee 150A are considered of prime importance.

Most vehicles launched from Wallops Island have a liquid fueled sustainer or liquid second stage. The propellant consists of inhibited red fuming nitric acid (the oxidizer) and a combination of aniline and furfuryl alcohol (the fuel). Fuel is drawn from its storage tank and forced into the vehicle's tank through a system of stainless steel piping and valves. Fuel storage tanks, pumps, gauges, filters and associated equipment are housed in the same building.

Proper flow rate is attained by manually adjusting the flow pressure as indicated by two 0 to 100 psi pressure gauges located downstream of the pump. Pumping pressure is normally about 15 psi. As the fueling operation nears completion, however, it is necessary to throttle the flow. Small variations in the discharge pressure represent relatively large changes in the flow rate, hence gauge accuracy is important. A similar procedure is followed in pumping the oxidizer to the missile. Gauges used in this service must be resistant to the corrosive effects of the caustic liquids used. Accuracy and dependability are critical factors.

For proper operation of the Aerobee's propellant system it is necessary to force the propellants

REDSTONE LEAK-TEST GAUGES

Table II

Number of Gauges	Pressure Range	Service
1	0 to 5000 psi	Measuring console source pressure
1	0 to 3500 psi	Measuring console source pressure
1	0 to 1000 psi	Measuring regulated pressure to missile
1	0 to 400 psi	Measuring regulated pressure to missile
2	0 to 3500 psi	Measuring various return pressures in the missile
2	0 to 1000 psi	Measuring various return pressures in the missile
1	0 to 400 psi	Measuring various return pressures in the missile
2	0 to 60 psi	Measuring various return pressures in the missile

Check list aids in engineering and procuring equipment; Vendor can often spot problems for project men

into the thrust chamber with compressed helium during flight. The vehicle is, therefore, fitted with a small helium tank which is filled at about 3500 psi prior to launching. The ground support system for providing this high pressure gas consists of a large storage vessel, compressor, stainless steel piping, pneumatic and manual valves, pressure gauges and associated equipment. Two 0 to 10,000 psi, and two 0 to 5,000 psi gauges are used in this system. These are also stainless steel bourdon-tube gauges. They must be of sturdy construction to withstand the repeated surges which occur in the lines during pumping.

The pressure gauges at Wallops are recalibrated at six-month intervals, and those in the propellant building are cleaned periodically because of the corrosiveness of the propellants.

Mace Power Pack—The Power Pack (Fig. 3) is one of several types of equipment for the ground support of the TM-76 Mace. In addition to supplying electrical power the unit services the missile in three other ways:

(1) A pneumatic system supplies high pressure air at 3500 psi and low pressure air within a 0 to 150 psi range for operating pneumatic tools.

(2) A hydraulic system supplying 15 gpm at 1750 psi (max.) is supplied for check out of the hydraulic system in the missile prior to flight.

(3) A ground air cooling system providing 25 pounds (min.) of free air at 30 psi for input air temperatures up to 103°F. to the missile.

Pressure gauges, mounted on the control panel monitor the three systems.

GAUGE SELECTION CHECK LIST

The accuracy with which fluid or gas pressures are measured is of vital importance during the prelaunch checkout. This checklist will give engineering and procurement personnel an understanding of the factors influencing gauge selection.

Measured Medium: Since the vital measuring element (bourdon-tube) is often exposed directly to the pressurized fluid or gas, it is important that it be made from the right material. Corrosive media, or those under extremely high pressure for example, call for a bourdon-tube fabricated from a metal such as type 316 stainless steel. It is resistant to most corrosive fluids and gases and pressures up to 10,000 psi. The gauge vendor can often aid by making specific recommendations to project men.

Pressure Range: The American Standard recommends a maximum working pressure, under steady pressure, of not more than two-thirds the maximum value on the scale. Otherwise, accuracy may not be maintained and the life of the bourdon-tube may be shortened. Hence, if the working pressure is 200 psi, the selected range should be 0 to 300 psi.

Ambient Atmosphere: This problem relates to the medium around the gauge, as for example, caustic propellants. Certain atmospheres can ruin an aluminum case selected for light weight. Thus a gauge should be selected which will operate over a wide range of atmospheric conditions, or the end use

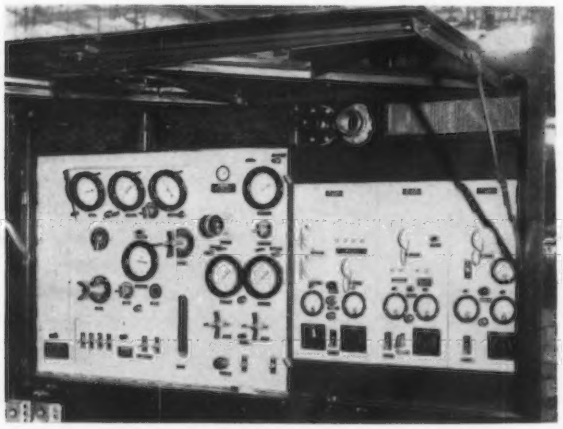


FIG. 2. MACE POWER PACK has electrical controls at right, hydraulic and pneumatic controls at left. Bourdon-tube dial gauges are prominent on the hydropneumatic panel. Goodyear Aircraft Corp. is unit supplier.

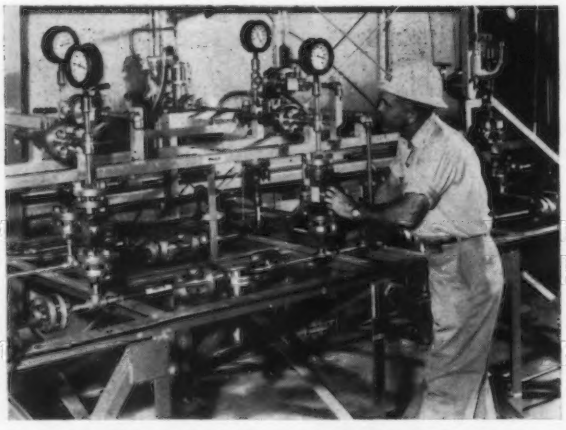
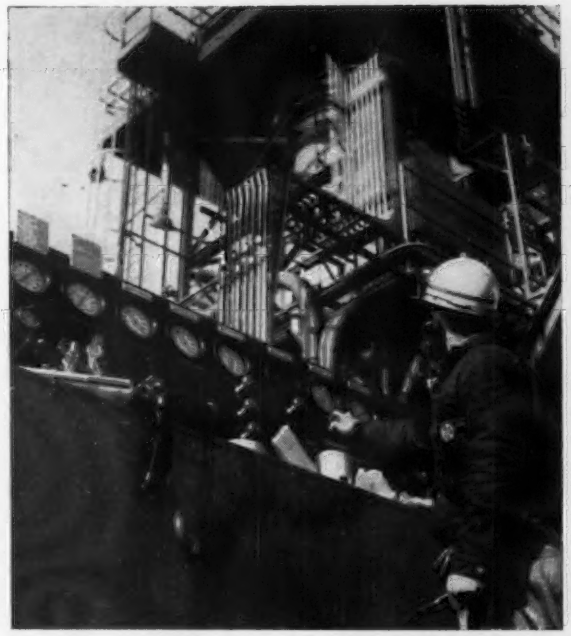
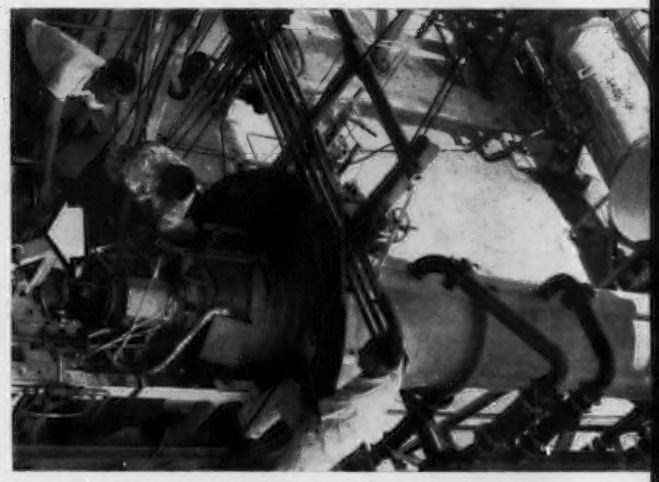


FIG. 3. LINE-MOUNTED GAUGES at NASA Wallops Island Facility are used to monitor flow of helium to storage tanks. Stainless steel bourdon gauges range from 0 to 10,000 psi dial readings.



ROCKETDYNE TEST STAND in California Mountains shows typical array of bourdon-tube dial indicators. Panel shown is for liquid oxygen and RP-1 fuel. Atlas, Thor, Jupiter engines are checked here.



INSIDE FIRING CHAMBER for altitude testing of LH_2-LO_2 Centaur engine, Pratt & Whitney technicians use dial type gauge (arrow) to monitor critical gas pressure. Camera is also mounted inside chamber.

of the equipment should be specified.

Wear Conditions: Pulsating pressures, sudden shocks and gauge vibration can seriously affect accuracy and cause excessive wear of the gauge mechanism. A number of devices are available which can be inserted into the gauge socket to minimize the effects of sudden pressure changes.

These are called pulsation dampeners. A variety of such attachments are available to suit the various pressures and fluids. The gauge and the attachment should be selected as a unit. The vendor can usually provide the project engineer with specific information for making intelligent decisions.

Connections: Soldered, welded, threaded and soldered, or threaded and welded are the commonest connections. Soft-solder joints are used for low pressure applications and for operating temperatures to 150°F. Silver soldering or silver brazing is used for medium pressures, while welding is used for high-pressure applications. Gauges should always be installed with the face of the dial in a vertical position with the midscale point in a perpendicular line with the bottom of the gauge.

Mounting: If the gauge is to be mounted in other than a vertical position, the position should be specified so that the gauge can be calibrated under operating conditions. Gauges with connections in positions other than the standard six o'clock are also available. The connection position should be specified by the engineer so that the dial can be properly aligned.

Required Accuracy: Accuracy is generally expressed in terms of percent of scale range. It should never simply be expressed in percent without the qualification. The degree of accuracy required depends upon the conditions of service, actual need for precise readings versus trend indications and probable maintenance care to sustain the accuracy. Usually, the more rugged the service, the greater the compromise between accuracy and costs. Related to gauge accuracy is reproducibility—the ability of the gauge to give the same reading for the same applied pressure time after time. This may be more important than the actual accuracy if the only purpose of the gauge is to tell a technician when to do something.

Readability: Readability and accuracy do not basically influence the selection of drawn-case gauge sizes. However, relatively large numerals on large size dials do ease the readability where, for example, there are physical limits on how close the observer can approach the gauge to read it. More pertinent are the limitations placed on space for equipment or panels. For Grade A and Grade AA gauges, commonly available in sizes over 4½ in., the values of the smallest graduations do vary with size. These values are closely related to the guaranteed accuracies of the gauge. Little is gained by insisting on finer graduations than are compatible with gauge accuracy.

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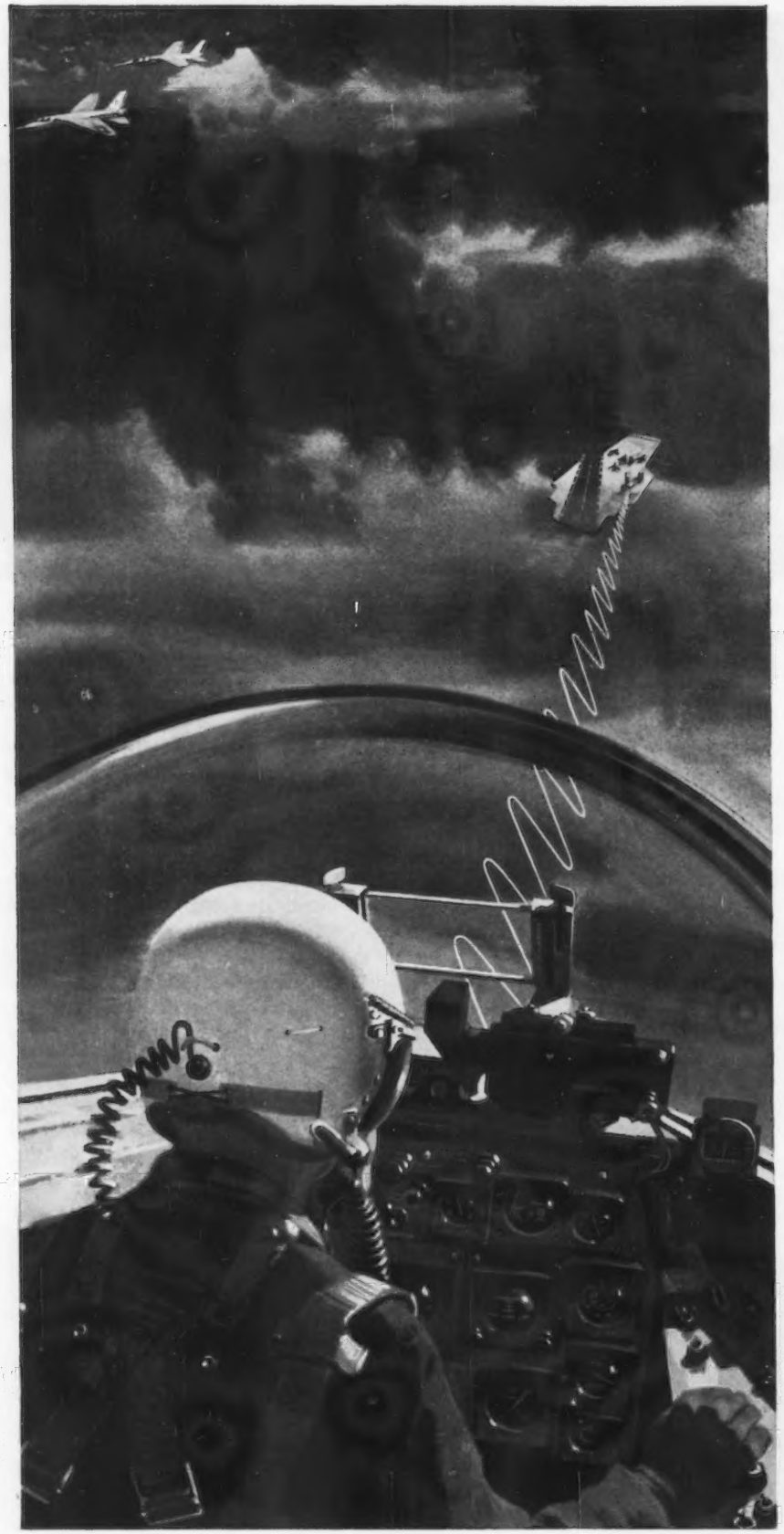

expressway for automatic all-weather landings

The Steel Products Engineering Division of Kelsey-Hayes is developing the radar antenna mounts for **Bell Aerosystem's** All-Weather Automatic Landing System. Designated AN/SPN-10 by the Navy, the system has been selected for use aboard the U.S.S. Enterprise and other nuclear powered carriers.

Since 1914, Speco has been a vital force in the nation's aviation and defense programs . . . and since 1949, has provided radar componentry for Titan, Hawk, Nike-Hercules, Nike-Zeus and many other guidance systems. For further information, write Speco Division, Kelsey-Hayes Co., Springfield, Ohio.

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K H

Republic Gears For Space

Seven integrated R&D labs opened to keep pace with technical progress; Allow study of complete spectrum of aerospace problems; Simulation and ground-testing taking on new importance as space era begins

by John P. Kushnerick

Republic Aviation is reaching. From a three-level brick building named for one of the men whose foresight put the company on top of the heap in the aircraft industry, Republic is reaching for the stars. The building at the southeast corner of Republic's 530-acre tract at Farmingdale is called the Paul Moore R&D center. It houses 7 applied research laboratories.* In them 500 specialists (⅔ with masters degrees) will lay the firm foundations from which Republic hopes to push to giant status in the space industry.

Equipping and staffing the labs will suck up $14 million in company funds.

Go On Green — Is Republic walking in a path already trod by military and NASA research facilities? Dr. William J. O'Donnell, chief engineer for Applied R&D thinks not. "Government cannot afford to subsidize the education of every firm that wants to do space business. Nor can it provide all of the informational inputs. We don't subscribe to the adage that knowledge is power . . . but, it does breed power. With the right kind of marketing we can use the knowledge we gain here to make Republic a space age power.

"When they flash the green light on something like Apollo, you've got to be ready to go."

Life Sciences—Man's needs and limitations in the space environments are still a big question mark. Republic hopes to find some of the answers in a 13-ft-diam, 30-ft-long space chamber. Conditions and environments up to 150 mi altitudes will be simulated. Man, materials, and equipment will be evaluated. Solar radiation and vibration are planned as part of the combined environment test capability.

Nuclear Radiation—Nuclear engines, the real hope for space conquest, and cosmic radiation in space, produce violent effects on man and equipment. Republic's R&D facilities now include two hot cells, 8 x 8 x 15.6 ft for finding ways to beat radiation. The 40,000 curies of Cobalt 60 used as a "source" represent the largest single shipment of radio active material to enter U. S. from Canada.

Republic says their space laboratories do not duplicate existing facilities any where in this country, but they are competitive. Each has been equipped in such a way as to support corporate activity in aeronautics and astronautics and in addition and something new to the nation's research facilities.

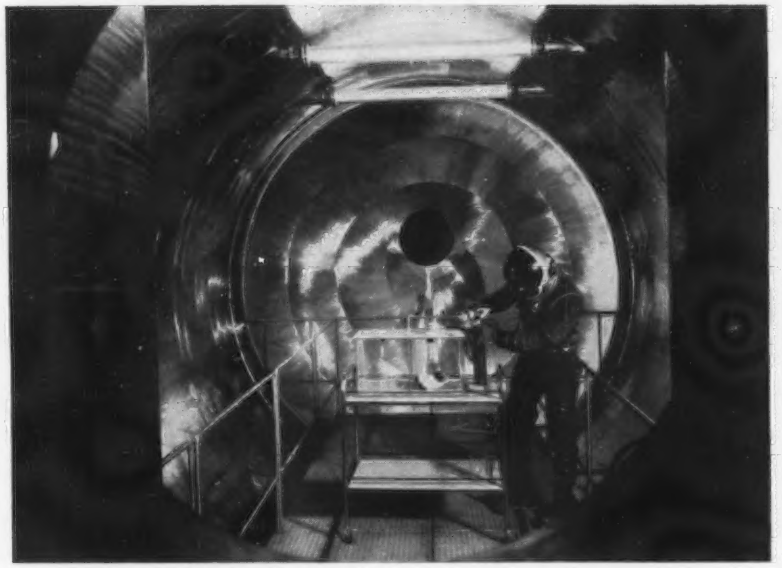
Dr. William J. O'Donnell
". . . go on green . . ."

Reentry Lab—Principal piece of equipment in the Reentry Simulation Lab is a 96-ft hypervelocity shock tube. It has a 24-in. diam test section that allows model studies at Mach 20 conditions.

A megawatt Arc-Jet is another piece of equipment used in high temperature studies. It reproduces temperatures encountered at speeds of 10,000 ft/sec. This heating device departs from the traditional consum-

**(1) Reentry Simulation, (2) Nuclear Radiation, (3) Life Sciences, (4) Guidance and Control, (5) Electronics, (6) Materials Development, (7) Fluid Systems. The labs are backed up by a trio of wind tunnels trans, super, and hyper sonic.*

Research Center will support corporate-wide planning; Technologies from VTOL to space seen as challenges



INSIDE SPACE CHAMBER, Republic will study man and equipment at 150-mi altitudes. Chamber has 13-ft diam and 30-ft length. Solar radiation and vibration equipment are planned-for capabilities. Inhabitable part of Apollo can reportedly be accommodated.

MACH 20 SHOCK TUBE is principal piece of equipment in Reentry Simulation Laboratory at Republic. Other gear includes a 50-ft ballistic range, and a megawatt arcjet.

NAVIGATION AND CONTROL laboratory is equipped to build and study complete systems or electronic capacitors like one millionth inch thick device shown. Thin-film techniques are getting heavy attention to cut size and weight of computer logic circuits.

PROJECT APOLLO studies are underway at Republic with company funds. Model is based on NASA's original inputs for 3-man capsule. It is being used in the Space Environment and Life Sciences Lab. Windows are for viewing subjects.

able carbon electrode. Contamination is thus minimized.

A light hydrogen gun that fires projectiles at speeds up to 26,000 mph to simulate meteroid impact, and a 41 mm shock tube round out the reentry simulation equipment.

Electronics Laboratory — Republic says that antennas are the bottleneck of any communications system. Work in the Electronics Laboratory will concentrate on antenna studies using a uniquely shaped anenhoic microwave chamber. Electromagnetic waves within the chamber perform essentially in the same way as in empty space. Republic is also looking at the possibility of using the ionized layers that form around high speed vehicles as antennas.

Guidance-Control Lab—To develop effective guidance and control systems for future aerospace vehicles, Republic is working in 3 major scientific areas:

- Physical optics
- Solid state physics
- Low temperatures physics

One project in development with company funds is a stabilized "moon tracker." Coupled with a chromator and ephemeris (day-to-day position indicator) it will give basic long-term navigation inputs for space vehicles.

Republic has a small LASER which it is using for study of compact, high-intensity, coherent light sources.

Much of the work in the Electronics Lab has direct technological spill-over into the Guidance Lab.

Fluid Systems Lab — An Air Force contract to design and develop materials and components for a 1000°F-hydraulic-system makes the Fluid Systems Lab nearly self sufficient.

Republic feels it must have facilities for pneumatic and hydraulic research to be in the proper position for designing and managing future aerospace systems. Minute servo mechanisms and complete control systems are being studied.

Facilities include a 15-ft, three-chambered oven that can be used to evaluate systems at 5000°F and 1900°F. Special emphasis is being placed on exotic fluids at the present time.

Materials Laboratory — Structural integrity is still the basic problem of aerospace vehicles. In its Materials Development Lab, Republic will use 72 pieces of specialized equipment to discover, make, fabricate, and evaluate new materials. The knowledge gained in the six other labs, the company says, would be worthless if the materials lab could not translate it in sound structures.

Wind Tunnels—Supporting the labs is a set of wind tunnels. Capabilities extend from sub to supersonic at present. Reentry problems at speeds up to Mach 14 (9240 mph) will be studied in a new $750,000 hypersonic tunnel still under construction. Known as a "pebble-bed" tunnel, the new facility provides for the preheating of air by nearly a million ceramic pebbles a half-inch in diameter. These are heated to 3000°F to warm the air before it is forced through the various tunnel nozzles. The test section of the tunnel will be able to handle models up to a foot in diam—a respectable size large for a hypersonic facility of this type.

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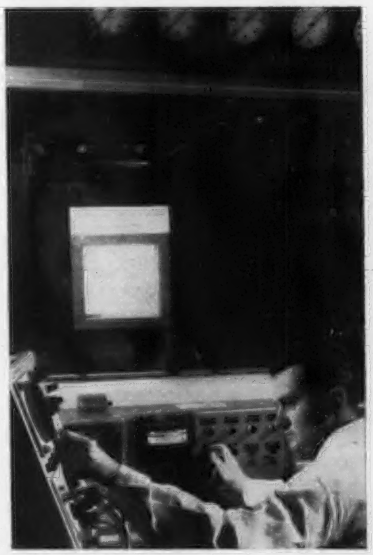


FLUID SYSTEMS LAB is already self sufficient. Republic has Air Force contract for studying 1000°F hydraulic systems for aerospace craft. Pneumatics also studied.

MATERIALS LABORATORY is one of seven which together give a capability of studying the complete spectrum of aerospace problems. Materials and components can be tailored, molecule by molecule, to the rigors of space flight in this lab.

Planning Long-Range Reliability

Air Force Ballistic Missile Division program stresses functional testing under combined environments, enhances fluid-system-component reliability

by Sherwin Lewis, Member of Technical Staff,
Space Technology Laboratories, Inc.

and Capt. James P. Cooper, Project Administrator,
Directorate of Propulsion Development, AFBMD

An Air Force Ballistic Missile Div. program has developed reliable pressure switches, regulators, solenoid valves, and liquid oxygen tank vent-valves for missile systems. Development was based on rigorous standards and the most critical extremes of environment.

Emphasis was placed on concept of functional testing under combined environments. Contractors selected for "universal components," — solenoid valves and pressure switches—were guided by rigid size, weight and environmental requirements. Contractors working on more complex components, i.e., regulators and vent valves, had to match functional and dynamic requirements of a particular missile system which was itself in a state of flux.

Pressure Regulators—The Air Force program included an extensive effort to mathematically-synthesize pneumatic regulators.

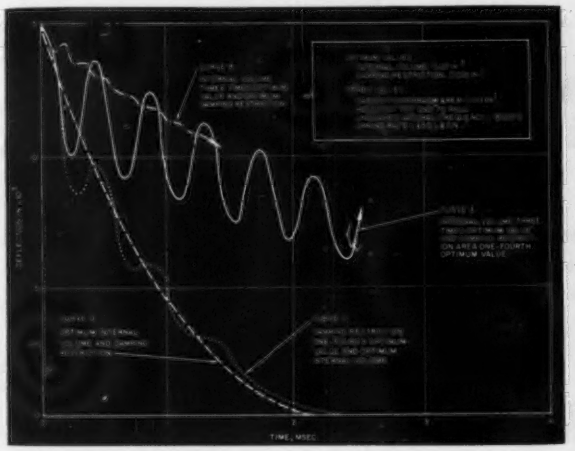
Mathematical simulations of sensing lines and transmission lines were made by Robertshaw-Fulton Controls Co. (AFBMD-TR-60-72). Next, an existing regulator was simulated with fair correlation. Finally, a regulator was synthesized through a non-linear computer simulation. Flow characteristics of the poppet and diaphragm effective-area were derived empirically.

Insight into the operation of the pneumatic servomechanism was obtained from the non-linear analysis; and a modest degree of synthesis was accomplished by varying certain design parameters such as orifice sizes, effective area, and spring rates. But, the analog computer fell far short of total synthesis. Cut-and-try remained the basic design method. To simplify the analysis, a linear system representation was made.

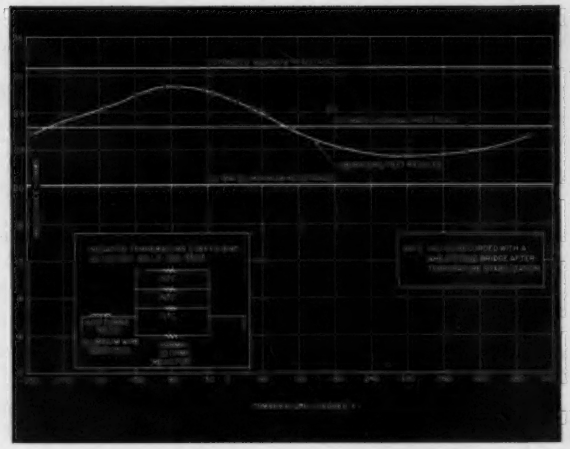
The second regulator contractor, Rocketdyne, chose the principal design parameters from a static force balance analysis. Mathematical analysis was used where possible to design a stable configuration (AFBMD-TR-60-85).

It had been intended to completely simulate the dynamic performance of the regulator with a digital computer. This method dispenses with the complicated circuitry and setup time of the analog; and there is no problem representing non-linearities, limit stops, and discontinuities.

The digital computer like the analog was helpful in gaining insight into the dynamic operation of regulators, but like the analog it was not completely successful in uncovering instabilities. A problem curtailing the use of the computer model is illustrated by the fact that the computer had to solve 55 equations 15,000 times, to simulate 0.3 sec of operation for just the regulator actuator. Computer time per run was long enough to make computer runs relatively expensive. Therefore, the complete regulator was never simulated.



TIME RESPONSE is shown of a dashpot and spring-mass system, to dampen oscillations, as calculated by a digital computer. A nearly-optimum critically-dampened response is seen in curve "D."



CONSTANT CURRENT was maintained over wide temperature range through use of constant-current resistors, an aluminum coil, and negative temperature coefficient resistors in modified solenoid.

Temperature Compensator Development

SOLENOIDS—One problem in missile systems is that in the short time from checkout through launch and flight, components are subjected to a wide range of temperatures. The two solenoid-valve developers in the program were confronted with the simple physical fact that solenoid current-flow, is directly proportional to temperature, changing by a factor of about 12 over a 500°F span.

A North American report (AFBMD-TR-59-18 & TR-60) describes a solenoid modification which combines constant-current resistors and the copper coil with the following results:

Coil Type	Ambient Temp.	Resistance (Ohms)	Current (Amperes)	Voltage
Uncompensated	165°F	51.4	0.466	24
	Room	34.4	0.695	24
	−320°F	4.17	7.18	30
Compensated	165°F	29.8	0.80	24
	Room	21.25	1.13	24
	−320°F	11.66	2.58	30

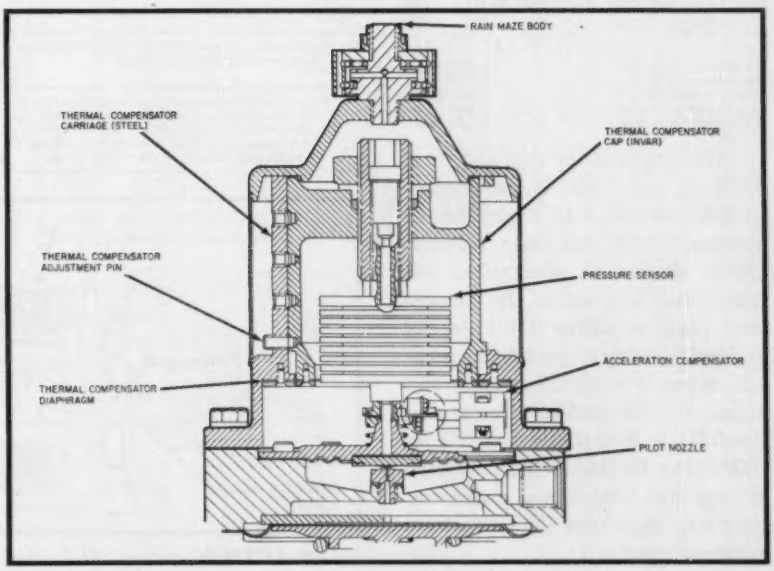
An even more ambitious effort is reported by AiResearch (AFBMD-TR-60-179), to maintain constant current over the wide temperature range. Here, constant-current resistors, an aluminum coil, and negative-temperature-coefficient resistors were used.

Another problem—mechanical repeatability of certain components is also adversely affected over a large temperature range. At low temperatures, springs become stiffer and conventional regulators and pressure-switches shift to higher control or actuation pressures.

Each contractor attempted temperature compensation in a manner appropriate to the individual problem as follows:

REGULATORS — Regulation shift can result from temperature contraction (or expansion) of the sensor and its supporting structure, and changes in spring modulus of elasticity. Ordinarily, the latter effect is by far the largest. Between —50°F and 150°F, Ni-Span C can be used to negate the effect because it has no appreciable modulus change; but from —320°F to 165°F, it is necessary to install a compensator. Rocketdyne designed a compensator based on differential

SENSOR BELLOWS stiffening at low temperatures, causes the confined length to increase, thereby maintaining a constant force to ±0.1 psi from 70°F to –320°F.



Snap-action pressure-switch mechanism adjustable 10 to 1000 psig, operates in liquid helium at —452°F and 65 g vibration environment

expansion between Invar and stainless steel. As the sensor bellows stiffened at low temperatures, the confined length increased, thereby maintaining a constant force. Effective length of the Invar can be changed as required by a simple adjustment. The compensator can keep the pressure setting drift to within ±0.1 psi from 70°F to —320°F.

Temperature compensation achieved by Robertshaw-Fulton was simply by backing up each critical spring with a bi-metallic disk manufactured by the W. M. Chase Co., Detroit.

PRESSURE SWITCHES—Aerojet General made extensive efforts to achieve temperatures compensation (see Table I) in a bellows-actuated, column-spring pressure-switch (AFBMD-TR-59-23).

The second pressure-switch contractor, the Frebank Co., compensated temperature by varying the material to a load-adjustment ring and an actuation shaft. The following is a list (AFBMD-TN-60-85) of the materials affecting compensation and their dimensional change from ambient temperature to —320°F:

416 stainless steel	0.0021 in./in.
303 stainless steel	0.0027 in./in.
Beryllium copper No. 25	0.0028 in./in.
2024-T4 aluminum alloy	0.0038 in./in.
A231B magnesium alloy	0.0053 in./in.

The length of the ring and shaft (0.58 in. and 0.600 in.) multiplied by the difference in expansion as compared with the body material (2024 aluminum), determines the differential contraction. If the setting position shifts 0.001 in. at —320°F, then the proper compensation would result from using 416 stainless in the load-adjustment ring ((—0.0038 + 0.0021) x 0.580 = 0.000986). By this method the contractor has maintained extremely tight tolerances over the entire temperature band.

Snap-Action Pressure Control—To meet the pressure-switch requirements, Frebank Co. developed a basic mechanism giving two pressure switches, covering an adjustable range of 10 to 1000 psig. These units have operated reliably while immersed in liquid helium at —452°F, and while subjected to vibrational forces in excess of 65 g.

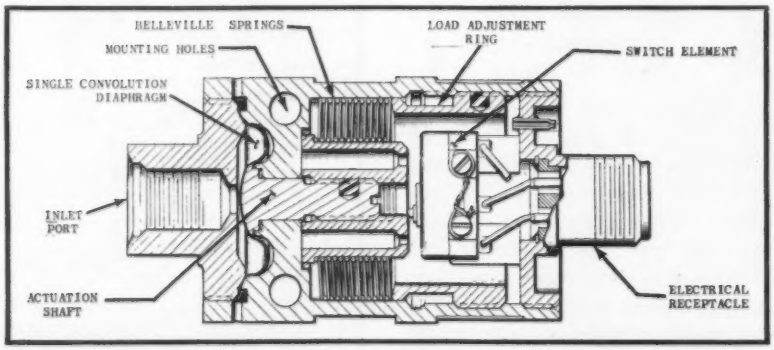
Same mechanism has been utilized in the development of a family of single, non-modulated pressure-control valves suitable for hyper - environmental applications. Basic mechanism consists of a stack of belleville springs.

An electrical switch or a pilot-valve can be set, in the snap action region, so that there is no loading of moving element prior to actuation. This results in a basically vibration-resistant mechanism, but as such can be used only in relatively-crude devices. Modifications of this device consist of (1) pre-deflecting the spring beyond the first reflex-point, and (2) stopping prior to the second reflex. As the load is increased, nothing happens until the load exceeds the force corresponding to the pre-deflection, where the spring becomes unstable and snaps to the post-deflection stop. When the force is decreased, the spring snaps back at the intersection of the post-deflection stop with the negative slope. By manipulating the two vertical lines, the actuation and dead-band can be adjusted.

The pressure switch developed by Frebank uses the snap-action concept with de-actuation pressure between 55 and 97 per cent of the actuation pressure. Unit is designed to operate within a two per cent

Table I—Temperature Compensation in a Bellows-Actuated Column-Spring Pressure-Switch

COMPENSATION METHOD	REMARKS
(1) Adjacent parts with same coefficient of expansion.	Not adequate. Change in modulus governing.
(2) Utilizing the gas pressure inside sealed bellows, where low temperature causes internal pressure to drop, thereby compensating for increased spring stiffness.	Useful only for lower setting switches (400 psia). Sealing bellows with high internal pressure would make this technique more general, but would introduce a potential leakage problem during assembly and storage.
(3) Use of aluminum yoke with steel spring in addition to bellows sealed at 14.7 psi and 70° F.	Limited compensation; excessive low temperature travel resulting in high stress; not versatile enough for the varied spring rate of pressurized bellows.
(4) An auxiliary bi-metal spring operating in parallel with the column spring which provides a nominal force against the bellows at —300° F. This force increases with rising temperature to compensate for the decreasing load capacity of the column spring.	Successfully demonstrated, but not completely developed.



SNAP-ACTION switch can be set to actuate between 100 and 1000 psi.

PERFORMANCE OF EQUIPMENT UNDER COMBINED ENVIRONMENTS

COMPANY OR ORGANIZATION	Facility Design	VIBRATION: Shaker Mfg. and Model Type Force Output *Direction	VIBRATION: Frequency (cps) and Force Moving Element and Fixture Wt Max Specimen Wt	ACCELERATION: Centrifuge Mfg. and Model **Radius Acceleration	Test Fluids	Temperature Humidity	Altitude (ft)	Slip Rings	Swivel Joints Manufacturer	Remarks
Missile Div. North American Aviation, Inc., Downey, Calif.	Shaker mounted on centrifuge	MB C6C (2 units) Sinewave 200 force lb normal and radial	5 to 2000 ≐ 25g 3 lb 5 lb	Genisco C-159 (1) 32 in. (2) 22.5 in. 15g	Cryogenic liquids and gases	Fluid −320 to +300°F ambient −320 to +300°F 100% R. H.	150,000	32 Rings	2 Fluid swivels 3000 psi Cryogenic liquids and gases NAA design	Electrical-hydraulic drive Shakers operated in phase to damp-out reaction forces.
AiResearch Mfg. Co. Garret Corp. Phoenix, Ariz.	Centrifuge mounted on shaker	MB C-100 Sinewave 12,500 force lb normal	5 to 2000 ≐ 25g ***285 lb 5 lb	AiResearch 10 15	Cryogenic gases	Fluid −300 to +250°F Ambient −300 to +250°F 100% R. H.	90,000	30 Rings	1 Vacuum swivel	No pressure swivels, fluid storage and heat exchanger on-board centrifuge. Facility not completely checked out. Temperature, altitude, and R. H. quantities shown represent design parameters.
Aerojet-General Corp., Azusa, Calif.	Centrifuge mounted on shaker	MB C-25HB Random and/or sinewave 2500 force lb Radial and normal with modifications	5 to 2000 ≐ 25g (with amplification) Fixture and moving element estimated at 150 lb 5 lb	Aerojet 10 in. est. 30g	Cryogenic liquids and gases	Fluid −300 to +300°F Ambient −300 to +300°F 100% R. H.	100,000	.....	.....	Test facility not completed. Feasibility demonstrations only. Quantities shown represent design parameters.
Stellardyne Laboratories, El Cajon, Calif.	Shaker mounted on centrifuge	Savage V1000A Sinewave 500 force lb normal and radial	5 to 2000 ≐ 25g 13 lb (includes environmental chamber) 7 lb	Stellardyne (1) 56 in. (2) 72.5 in. 20g	Cryogenic liquids and gases Fuel and hydraulic fluids	Fluid −300 to +450°F Ambient −320 to +450°F 100% R. H.	120,000	40 Rings	3 Passage swivels 3000 psi Designed and fabricated by Stellardyne	Savage V1000 shaker can be modified to 750 force lb. Vacuum pump mounted on centrifuge
Wyle Laboratories, El Segundo, Calif.	Shaker mounted on centrifuge	MB C-25H Random and/or sinewave 3500 force lb normal and radial	5 to 2000 ≐ 25g 75 lb 65 lb	Wyle (1) 108 in. (2) 130 in. 20g	Cryogenic liquids and gases Fuels and oxidizers Hydraulic fluid	Fluid −320 to +500°F Ambient −320 to +300°F 100% R. H.	250,000	Instrumentation 75 rings Electronic-Micro-Molding Co. Power 24 rings Superior Carbon Co.	2 Concentric swivels Cryogenic fluids 1" and 4" (3000 psi) ½" and 3" (100 psi) Chicksan Co. and Barko Mfg. Co.	Centrifuge driven by 290 hp gasoline engine with hydraulic torque converter. Centrifuge mounted on trailer for transport between test sites.
WADD Wright-Patterson AFB, Ohio	Shaker mounted on centrifuge	Calidyne Model 44 Sinewave 550 force lb normal and radial	5 to 2000 ≐ 25g 12 lb 10 lb	Unknown (1) 72 in. (2) 80 in. 45g	Gases, hydraulic fluid, water, or liquid N_2	Ambient −65 to +250°F 100% R. H.	.....	Instrumentation 48 rings WADD design Power rings	.....	Fluid and gas storage on-board centrifuge. Double disk construction Electrical-hydraulic drive.
AFFTC, Edwards AFB, Calif.	Shaker mounted on centrifuge	MB C-50 Random and/or sinewave 5000 force lb normal and radial	5 to 3000 ≐ 25g 40 lb 160 lb	Rucker (1) 156 in. (2) 186 in. 30 to 50g	Cryogenic liquids and gases Fuels and oxidizers Hydraulic fluid	Fluid −300 to +500°F Ambient −320 to +500°F 100% R. H.	300,000	Approx 100 total	2 Concentric swivels Cryogenic fluids 1" 6000 psi and 4" 1000 psi 1" and 2" 1000 psi	Facility in design stage. Quantities shown represent design parameters. Electrical-hydraulic drive 20 ft diam disk construction, shaker on extension.

* Relative to accelerational force. ** Radius to component centroid. (1) Shaker vertical (normal). (2) Shaker horizontal (radial). *** Moving element plus fixtures = 285 pounds, centrifuge = 200 pounds, for a total of 485 pounds.

Combined-environment tests were run to discover failures under in-flight conditions. Analyses of results on seven different components follow.

• Accumulator Relief Valve (Titan)—A repeatable galling failure was induced after 20 cyc, comparable to a life failure after 10,000 cyc. Upon modifications, unit operated satisfactorily.

• Solenoid Valve (Atlas)—Leakage was induced by combined environmental testing similar to that induced by dual environmental testing (vibration and temp.).

• Fuel Tank Regulator (Atlas)—Total failure resulted apparently accelerated by combined testing, however there was some question on appropriateness of environmental levels before and during test.

• Engine Regulator (Atlas)—Performance was apparently improved by combined environmental testing.

• Pressure Switch (AFBMD Program)—During development several switches were extensively tested with single and dual environment but later failed under combined environments. After modifications, the design operated successfully.

• Solenoid Valve (AFBMD Program)—During development leakage was induced by acceleration in line with the pilot poppet, combined with vibration perpendicular to the poppet. The phenomenon could be duplicated by increasing the vibration intensity without acceleration.

• Nitrogen Start Check Valve (Titan)—No apparent effect.

Components tested under combined environments including acceleration up to 15g in any axis

tolerance while subjected to any combination of the following environments:

Vibration	5 to 2000 cps at 25 g
Acceleration	up to 15 g in any axis
Ambient Temp.	−300°F to 200°F
Altitude	Sea level to any altitude
Humidity	0 to 100 per cent with condensation
Mounting	any attitude

A comparable switch was developed which is operable between 10 and 100 psig.

Extreme Environments — Each contractor in the AFBMD component program was required to design components capable of operating under any combination of the above environments.

Detailed sub-component developments disclosed in the final reports describe analysis, design, and exhaustive testing of actuator diaphragms, bellows sensors, acceleration compensators, coulomb friction-dampers, static seals, etc. A typical sub-component problem involved the development of a low-leakage, poppet and seat configuration which would operate in excess of 10,000 cycles over a pressure range of 100 to 5000 psi pass 1.2 lb/sec. Helium with 800 psi upstream pressure can be capable of exposure to the environmental conditions described above. Each of the contractors experimented with combinations of soft metals, hard metals, and plastics. The lapped hard-metal poppet and hard-metal seat described in a North American Aviation report is typical of the solution.

Endurance tests of this seat and poppet in a piloted solenoid valve indicated the sealing characteristics obtainable in a high-flow valve. Typically initial leakage at 1-38 scim reduced to 0.58 scim after 10,000 cycles.

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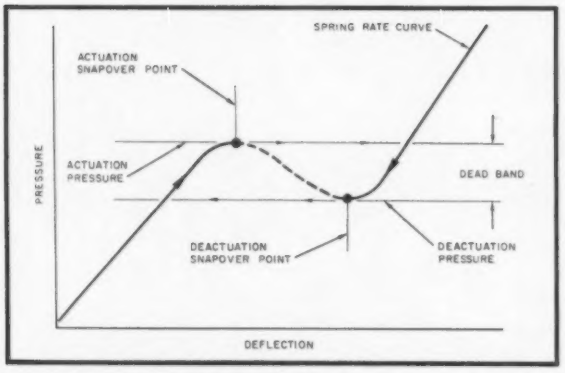
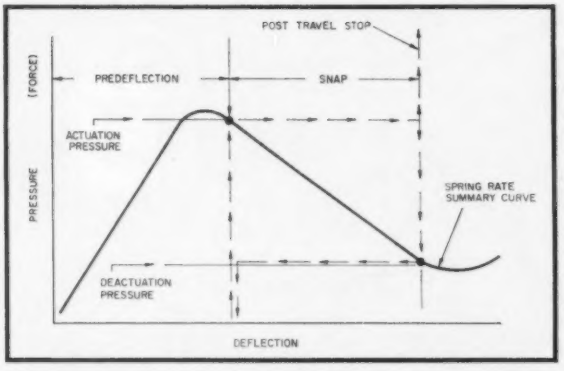
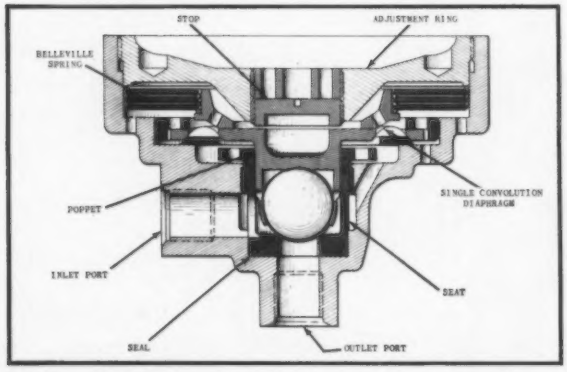


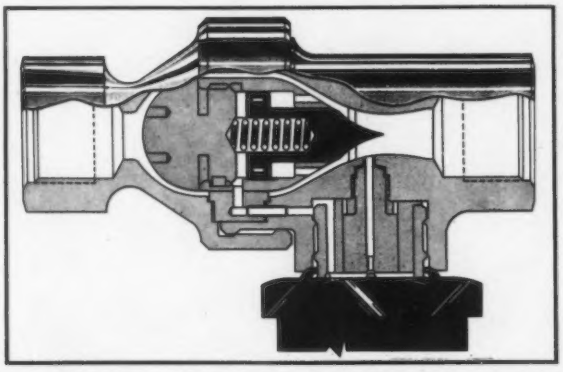
BELLEVILLE SPRING behavior (snap-action) has been used in development of non-modulated pressure-control valves for hyper-environment applications.



MODIFIED BELLEVILLE SPRING concept involves pre-deflecting the spring beyond the first reflex point, and positively stopping prior to the second reflex.



SNAP-ACTION gas-relief valve prototype, incorporating a single-convolution diaphragm, is actuated by belleville springs.



HIGH-FLOW, LOW-LEAKAGE solenoid valve for cryogenic use features a lapped hard-metal poppet and a hard-metal seat.

Design based on Boeing supersonic transport study.

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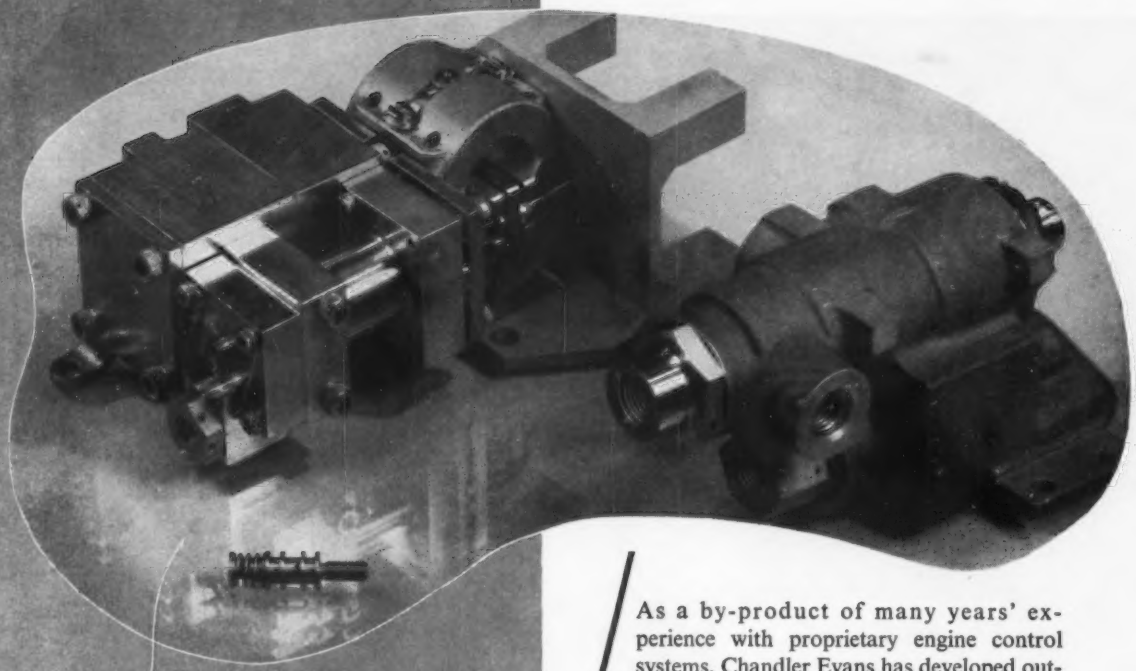

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*Left—hydrogen peroxide valve; right—jet engine flow divider; foreground—accelerating valve

For more detailed information on CECO facilities and subcontract capabilities, write Department S-2 or call R. M. Campbell, ADams 6-0651.

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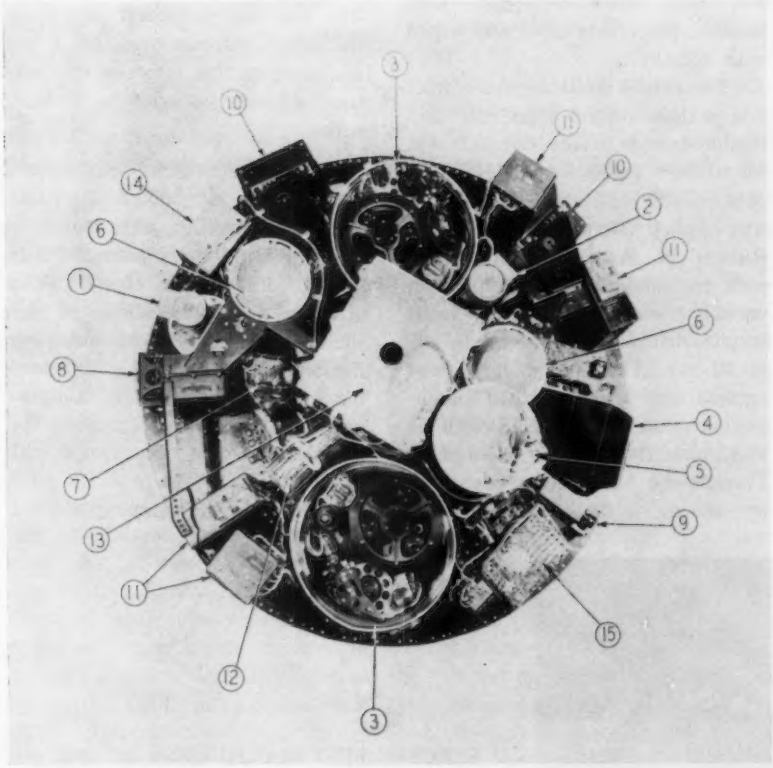


INSIDE TIROS II operating devices and systems, numbered as follows: (1) Wide-angle TV camera; (2) Narrow-angle TV camera; (3) television tape recorders; (4) Infrared system, 5-channel radiometer; (5) Infrared system electronics; (6) Electronic clocks for timing sequence of operations; (7) Relays for magnetic stabilization system controlling satellite's attitude; (8) Control box for electronic systems; (9) Infrared horizon scanner; (10) Electronic circuits for cameras; (11) Electronic circuits for TV tape recorders; (12) Telemetry switches; (13) Antenna diplexer (covering storage batteries); (14) Automatic signal generator; (15) Fuse board and current regulator.

Uncharted hazards in space can cause failures in missiles and satellites. In Trios meteorological satellites, components power supply and circuitry are protected against some of these hazards by epoxy resins. These formulations serve as encapsulations, coatings, sealants and adhesives.

Each Tiros vehicle carries approximately 9,300 solar cells to provide power for cameras, recorders, transmitter, infra-red and associated equipment. The solar cells have total maximum output of 60 watts under optimum conditions. They are mounted in "shingles" of five cells on module boards which carry 80 cells each. Circuits—in parallel—are embedded in the boards to minimize the prospect of circuit interruption due to attack by micrometeorites. Module boards are mounted on aluminum panels—four to a panel. Circuitry is arranged for outputs of 14 to 28 volts.

Tiros module boards are made of a glass-cloth epoxy laminate selected for low-volatility characteristics in high vacuum. Out-gassing during space flight would have a harmful effect on functioning of satellite components. Module boards are designed with ridges for accurate positioning of "shingles" and to speed their mounting. They were produced by International Resis-

Hysol Corp. and Army Signal R&D Command join forces to develop special encapsulating and coating resin

tance Co., using Shell Chemical Company's Epon (R) resins.

Epoxy Adhesive — To attach solar cell "shingles" to module boards, and module boards to aluminum mounting plates, a modified epoxy resin structural adhesive was used. This adhesive was used in sheet form and consisted of a supported film on a light-weight glass fabric carrier. The product was made by Bloomingdale Rubber and is known as FM-97. It is a mounting medium of uniform dielectric gap thickness which helps protect Tiros circuitry by maintaining a uniform dielectric gap.

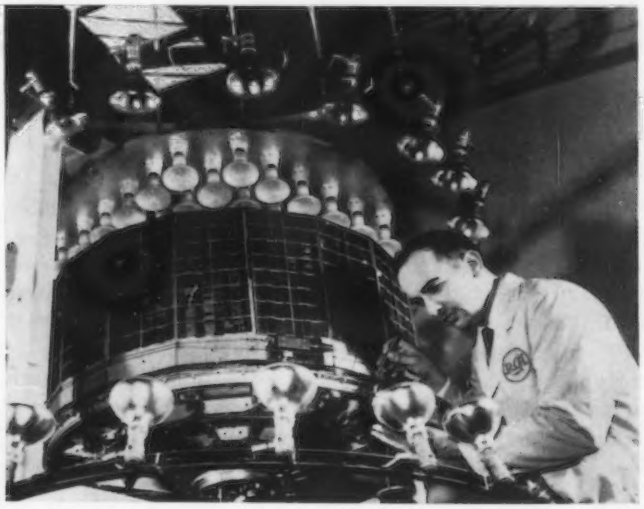
Mounting of the large number of solar cells and module boards on five Tiros vehicles was a major assembly problem. The use of a sheet product hastened the process greatly. The Epon-base adhesive was precut to size then refrigerated to preserve its shelf life. At 0° F, the shelf life is at least 225 days; at 40 deg F, the shelf life is at least 60 days.

Assembly of solar cells involved hand positioning a "shingle" of cells and a single precut section of adhesive on a module board cleaned of finger prints and grease. Each "shingle" was mounted individually until the module board was completed. Light pressure was applied to each assembly by placing a steel plate over it while being oven-cured at 200° F for 5 hr. Assembly of completed module boards to aluminum mounting plates was handled in the same manner. The plates had been given a Martin Hardcoat finish. Prior to mounting, the finish had been abraded lightly with medium grit emery cloth and wiped with solvent.

Prevents Vibration—As a fillet and sealant around solar cells and module boards to stop vibration and fill voids, a high-strength, 100 percent solids adhesive formulation was applied (Bondmaster M648, a Rubber & Asbestos Corp. two-part formulation based on Epon resins). It was mixed in very small batches because its pot life is 45 to 50 min. The fillet material was applied with artists brushes following oven-cure of completed modules and mounting plate assemblies. Though the formulation contained no solvent, it flowed well enough to be painted on. Room temperature cure overnight permitted ready handling of assemblies.

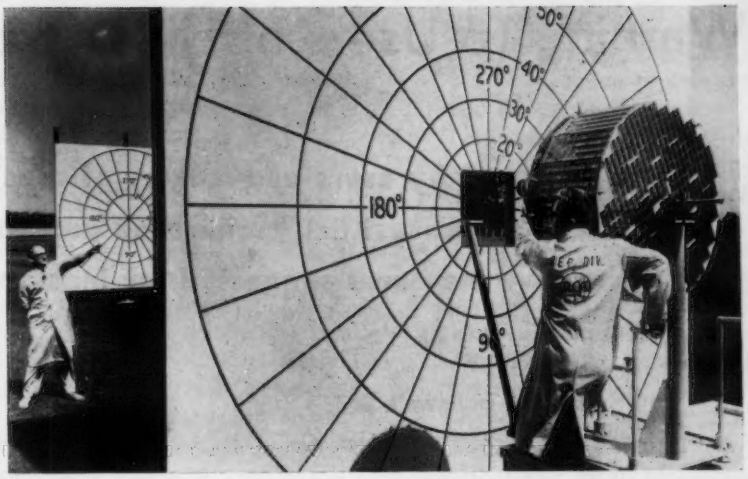
For a conformal coating to hold down and protect small parts and wiring, and for encapsulating miniaturized parts, an epoxy circuit made by Hysol Corp. was used. Hysol 12-006 was used to encapsulate or coat as many Tiros components as possible prior to assembly. The remaining parts were coated afterward by brush, spatula or air gun. The gun was needed to apply the thick and viscous oxide-filled formulation of this material that was used around batteries as a heat-sink.

The two-part polyamide-cured formulation was mixed by hand. Coated assemblies were cured at 150 deg F for a minimum of 2 hr in the walk-in oven. Hysol 12-006 serves as a moisture barrier of high dielectric strength with adequate flexibility and toughness to assure maximum protection to components. It is based on Epon resins and was developed in cooperation with the U. S. Army Signal Research & Development Command.



SPECIAL TEST MACHINE for magnetic orientation system that permits some control of the satellite's attitude in space is adjusted by RCA engineer Robert Wilkes. Spherical "cage," at top of photo, creates a magnetic field similar to that which surrounds Earth. By rotating Tiros II within the "cage," RCA engineers study operation of the orientation system. Lights above and around the satellite are used to test operation of the solar cells on top and sides of Tiros II.

CALIBRATION OF FOCUS and field of view of the television cameras in Tiros II is made with the aid of large "targets." Here, positioning of satellite is directed by Max Mesner (left), engineer in charge of TV camera design for Tiros, as Ralph Jordan rotates Tiros II on its mount for calibration of wide-angle TV camera. To prevent vibration and fill voids an Epon resin material, Bondmaster M648, was used as fillet and sealant material around the 9300 solar cells on the satellite.



ABOUT THE TIROS. . . . .

"TIROS" is a contraction of Television and Infrared Observation Satellite.

The Tiros II meteorological satellite was launched at 6:13 a.m. EST, November 23, 1960, from Cape Canaveral, Florida, and was injected into nearly circular orbit 13 min later. The satellite's primary instrumentation consists of two television cameras, to photograph Earth's cloud cover, and sensors to map solar and infrared radiation in various spectral bands. With the exception of the radiation equipment, Tiros II closely resembles the TIROS I satellite launched on April 1, 1960.

Over-all responsibility for the Tiros project rests with the National Aeronautics and Space Administration, and the operational phase is under the direction of NASA's Goddard Space Flight Center. The radiation experiments were designed, and the data storage and telemetry equipment associated with them were constructed, by Goddard, which is also analyzing the radiation data. Barnes Engineering Co., Stamford, Conn. under NASA contract, provided the radiation detectors. Except for the radiation experiments, the satellite was designed and constructed by the Astro-Electronics Div. of the Radio Corporation of America, Princeton, New Jersey, under contract to NASA. RCA was also responsible for the special ground-station equipment. The Delta launch vehicle was constructed by the Douglas Aircraft Corp.

The major differences between the instrumentation of the two Tiros satellites are in the addition of the infrared equipment in Tiros II and of magnetic instrumentation to control the orientation of Tiros II's spin axis.

Radiation Experiments — Tiros II carries two radiation experiments. One consists of five radiation detectors, oriented at 45 deg to the spin axis, which scan through a combination of the satellite's rotation and its movement along the orbit. These detectors measure:

- The Earth's albedo—the percentage of reflectivity of radiant energy, or light—in the spectral range 0.2 to 5 microns.
- Infrared radiation emitted by the earth and atmosphere combined in the range 7 to 30 microns.
- Emitted infrared radiation coming through the atmospheric "window" (the portion of the electromagnetic spectrum to which the atmosphere is quite "transparent") in the range 8-12 microns.
- Radiation from the water-vapor spectral band 6.3 microns ±5 per cent.
- Visible radiation in the spectral range 0.5 to 0.7 microns.

This visual channel is intended to provide maps of visible radiation for use in relating the television pictures and the non-visible-radiation maps.

The second radiation experiment consists of two sensors, one white and the other black, which together measure the heat balance of the portions of Earth's surface and atmosphere viewed by the wide-angle television camera. The white sensor measures heat radiation from the Earth while the black sensor measures both visible (reflected solar radiation) and heat radiation.

Magnetic Orientation Control—A satellite spinning in space can develop a dipole magnetic field similar to that of a small bar magnet as a result of closed current loops in the circuitry and of any magnetic materials present in the satellite. The magnetic dipole, interacting with the Earth's magnetic field as the satellite orbits, produces a torque—which slowly changes the direction of the satellite's spin axis in space, thus also changing the direction in which the television cameras are pointing. This effect was discovered in Tiros I.

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Warning To Users of High-Strength Fasteners

Complacency by users and makers of special-purpose hardware is causing "weakest link" failures in aerospace equipment; Corrective measures suggested for industry and Government

by H. Thomas Hallowell, Jr.
President, Standard Pressed Steel Co.

There has been an alarming increase in the number of cases where sub-quality fasteners have caused expensive failures. This has been caused by inadequate specifications by the user, poor fabrication practices by short-cut-minded fastener-manufacturers, and the lack of testing or policing by the users. The following are typical cases from the "Rogues Gallery" files of Standard Pressed Steel Co., to warn users of fasteners from unverified sources.

A particular series of pan head bolts with torquing recess were supposedly manufactured to specification MIL-S-7839. An airframe manufacturer experienced failure of these parts after tightening and prior to external loading. Inspection indicated two serious defects: cracks in the head-to-shank fillet area, and heavy surface carburization. These two conditions create a combination which is certain to lead to failure. Carburized surface had a hardness of Rc 54 and was susceptible to hydrogen embrittlement during cadmium plating. Failure was further aided by presence of cracks in the critical head-to-shank fillet area. In lab tests the parts failed under sustained loading.

These defective bolts resulted from poor forging, heat treating, and magnetic particle inspection practices by the manufacturer.

Airframe Bolts—This series of bolts (NAS 628-22) is heat treated from 180,000 to 200,000 psi, and is generally governed by NAS-496. In keeping with high quality bolt requirements, these parts should have rolled threads after heat treatment, freedom from decarburization, 100 per cent magnetic particle inspection, cold worked fillets, and ability to pass fatigue tests.

Examination of the parts revealed complete lack of metal removal on the shank and underside of the head, surface seams extending through the head-to-shank fillet and through the thread run-out area, and lack of cold working of the head-to-shank fillet area. Fatigue tests resulted in the head failures at 27,000 to 39,000 cycles. The specification requires a minimum average life of 65,000 cycles. The low fatigue life resulted from the lack of fillet stressing, and rough surfaces. Service failures were prevented only by the user's tests.

Missile Bolts—For this application, 5/6-in. 220,000 psi bolts were purchased to the user's print. Requirements defined a good high-strength bolt with threads rolled after heat treatment, and without decarburization. Metallurgical characteristics were to conform to MIL-B-7838, and controlled root radii to MIL-S-8879; head-to-shank fillets were to be cold worked.

Examination revealed that the threads were rolled prior to heat treatment. The bolts failed in fatigue at about 7500 cycles, compared to an expected value in excess of 65,000 cycles.

Contrary to the requirements of MIL-B-7838 the parts showed a partial decarburization in thread area. Root radii were 0.004 to 0.005 in. compared to a minimum requirement of 0.0065 in., and were not smooth and uniform. Thread runout was abrupt rather than fairing into the shank as required by MIL-B-7838. Also, head-to-shank fillet area was rough and not tangential to the underhead bearing area.

SURFACE DEFECT abundance and lack of metal removal on shank and head underside of NAS 628-22 airframe bolt caused head failure.

High Temperature Bolts—Requisites for high strength bolting for 900°F application include: rolled threads after heat treatment, diffused nickel-cadmium plating, no decarburization, controlled flow lines, and cold worked fillets.

Examination of counterfeit parts supplied to a user revealed an irregular fillet with a radius of 0.026 to 0.057 in. The specification requirement is 0.047 to 0.057 in. Their nickel and cadmium plating was not diffused. Plating without the diffusing treatment would be very susceptible to hydrogen embrittlement.

Micro examination indicated that the parts were hot upset. The forging operation was not controlled since the parts coarsened due to overheating. In addition, micro examination revealed 0.005 to 0.009 in. decarburization on the head bearing area, fillet, and shank. This indicated a lack of proper metal removal after heat treatment. Thread root radii were measured as 0.0068 in.; specified minimum is 0.0075 in.

Landing Gear Failure—The 1⅜-in. hex-head bolts in this case were used in the landing gear of a fighter. They were specified to have 230,000 psi minimum tensile strength, AMS 6427 (4330 modified) material, and cadmium plating to QQ-P-416. No requirement was made for rolling threads after heat treatment or for stressing the head-to-shank fillet area.

Examination of the failed part indicated that the plating was a bright cadmium cyanide, and bolt head was formed by machining from bar stock. It was determined that this service failure, one of several reported, was the result of fatigue.

The above cases reflect on the extent of laxity which presently exists in procurement, design, and fabrication of high strength fasteners. The loss of life, disrupted production schedules, loss of equipment, and waste of both public and private money are inevitable consequences.

To correct this situation, we recommend that the following requirements be established and conformed to for bolts heat treated in excess of 180,000 psi:

- All bodies, heads, fillets, and surfaces preliminary to thread rolling be ground so that all surface defects are removed.
- That grinding burns be cause for rejection.
- All threads be rolled in one pass after heat treating.
- Thread root radius conform to MIL-S-8879 specifications.
- That bolts have flow lines in the head fillet area conforming to the general contour of the outside surface.
- Any plating or surface treatment be effected so as to avoid hydrogen embrittlement.
- Tensile and shear test and verifications of the metallurgical properties accompany every shipment.
- That on every shipment of tension and shear bolts, tension-tension fatigue tests accompany the shipment, giving evidence of proper fatigue values for both tensile and shear.

Lastly, we recommend issuance of Government specifications that make the above quality standards mandatory and qualified products lists a part thereof.

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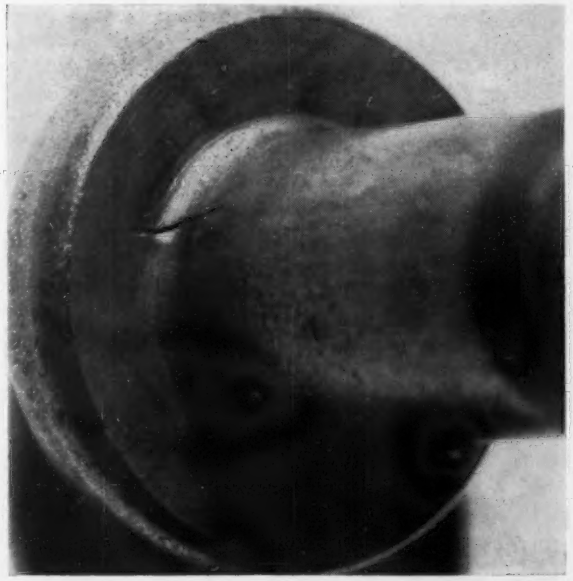
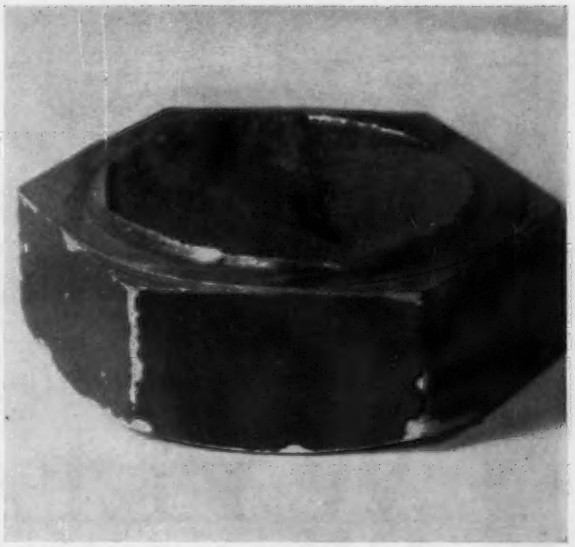


CRACK in the critical head-to-shank fillet area, and heavy surface-carburization caused failure of this NAS 1633-5 airframe bolt.



LANDING GEAR FAILURE resulted from bolt-head machined from bar stock instead of forging to specified 230,000 psi tensile strength.

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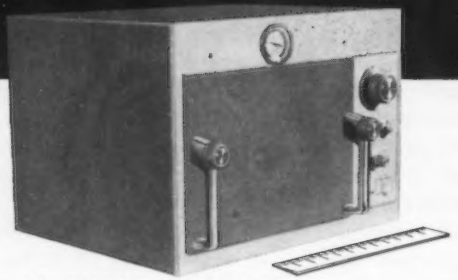

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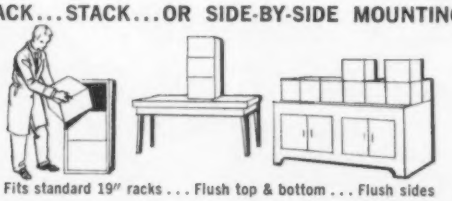

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ROBERT D. HAJNER and G. DEAN MCADOO have joined the Acoustics Division of Tenney Engineering, Inc., at Union, N. J.

DR. JOHN A. F. GERRARD named director of electronics engineering for Bendix-Pacific Div. of Bendix Corp.

L. R. BARR elected vice president and general manager at the Lear Romec Division of Lear Inc.

CLAUDE H. SMITH appointed general manager at the Ordnance Division of Minneapolis-Honeywell Regulator Co.

EZRA KOTCHER has been appointed to form and manage a San Francisco Bay area office for the Aerospace Corporation.

BENJAMIN F. RUFFNER named Chief of Technical Staff for Boeing's Aero-Space Division in Seattle.

R. E. BOCKSTRUCK named regional manager of field engineering in the midwest region by McCormick Selph Associates.

JOHN R. STEELE named manager of Beryllium metal development at the Beryllium Corp.

WILLIAM J. MARCY named General Manager of the ESCO Facility of Electronic Specialty Co., and RICHARD M. DONLEY takes over as Corporate Sales Manager.

DON N. LEE appointed operations manager at new West Coast facility of Rese Engineering, Inc.

DR. JOHN F. HICKS named associate director at Battelle Memorial Institute.

CHARLES J. THOMAS named manager of wheel and brake engineering operations at Goodyear Aircraft Corp.

A. H. RUDE selected as Board Chairman and W. E. ZISCH becomes Executive Vice President at Aerojet-General.

KENNETH O. ROEBUCK has been appointed program manager for the DYNA-SOAR program at Martin Denver.

JOSEPH E. TRANKLA has been appointed to the post of General Manager at the California division of Anadite, Inc.

R. R. GOLDSBOROUGH, JR., appointed manager of the engineering operations dept. at Sylvania's Reconnaissance Systems Lab.

H. HERBERT JACKSON has been named manager of the Nimbus weather satellite control system for General Electric Missile and Space Vehicle Dept.

NORRIS N. MURRAY appointed to develop new flight equipment and breathing systems at Sierra Engineering Co.

DR. RICHARD PANTELL, Associate Professor of Electrical Engineering at Stanford University, is now a consulting scientist with Lewis and Kaufman Electronics Corp.

DONALD W. WOHLGEMUTH appointed technical manager of pressure suit engineering at B. F. Goodrich Aviation Products Div.

J. CARL MOORE has been appointed director of manufacturing for the Aerospace-Rockets Division of Bell Aerosystems Company.

HERBERT H. HAUSER named technical assistant, to serve as technical liaison for European affairs at Ryan Electronics.

WILLIAM B. LURIE named chief engineer at Burnell & Company, Inc.

MAX LOWY has been named manager of Systems Integration for Gulton Industries, Inc.

DR. H. IGOR ANSOFF appointed to the new post of General Manager of the Information Technology Div. at Lockheed Electronics Co.

J. M. GARDINER named assistant to the president representing over-all operations at Thiokol Chemical Corp.

JAMES R. WESCOTT, JR., appointed marketing manager of Data Systems Operations at Sylvania Electric Products, Inc.

EDWIN L. CHAMPION named project engineer for aircraft and missiles weapons systems at Misco Precision Casting, and EDWIN L. ROGERS appointed head of ceramic core manufacturing department.

EDMUND R. GOSS is new manager at the West Coast Rocket Operations district office of Thiokol Chemical Corp.

DR. BERNARD E. KALENSHER joins Electro-Optical Systems Inc. as a senior physicist in the Fluid Physics Div.

DR. NICHOLAS FUSCHILLO named head of Solid State Physics section at Melpar Inc.

NEIL E. FIRESTONE has been named general manager of General Electric's Flight Propulsion Laboratory at Schenectady.

M. M. HENRY appointed assistant to the president of North American's Space and Information Systems Division.

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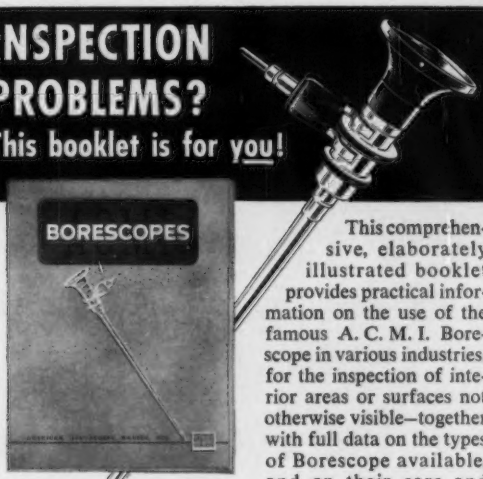

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Eight-page pamphlet tells how to use Teflon in sheets rods, tubes, tape and other standard shapes.—*Cadillac Plastic & Chemical Co.*

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Ceramics Chart

Inclusive property chart is a Valuable tool for any engineer using ceramics.—*American Lava Corp.*

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Data Transducer

Folder containing a glossary of pressure transducer definitions and describing the SP-2 series pressure transducers.—*Standard Controls.*

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Titanium for Missiles

A 14-page study summarizing the major application areas for titanium in missile construction. — *Titanium Metals Corp. of America.*

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Piezoelectric Devices

Booklet highlights developments in high-power handling abilities of all major piezoelectric substances.—*Clevite Electronic Components.*

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Shear Mounts

Bulletin describes elastomeric shear mounts includes outline drawings, load deflection charts, load ranges, spring rates and part numbers.— *Lyon Aircraft Services.*

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Plastic Coating

A four-page bulletin describing Pfaudlon 301, a corrosion resistant plastic coating for metal.—*The Pfaudler Co.*

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Support Services

"Support Services by Specialists," describes contract services for military contractors and the Armed Forces, also discusses the advantages managers of electronic warfare systems gain by subcontracting support service assignments to outside specialists.—*Federal Electric Corp.*

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Diaphragm Engineering

Elastomer-fabric diaphragms are described in a 4-page brochure, long stroke, rolling, pre-convoluted, and molded convolution diaphragms for either static or dynamic applications in aircraft and industrial use are discussed and illustrated in technical terms.—*Diaphragms Industries, Inc.*

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Four-page bulletin on a series of wide band noise generators includes specifications of the Stentor 203, 204 and 205 noise generators.—*Tenney Engineering, Inc.*

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Proprietary Rights

Reprints of the Denhem S. Scott speech "What Drafting Management Must Know About Proprietary Rights."—*The Garrett Corp.*

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Silicone Catalog

Catalog (CDS-129C) contains data pertaining to various silicone products, including a complete selector guide for silicone rubber.—*General Electric.*

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Miniaturized Relay

Electrical and physical characteristics of Series 200 miniaturized 10 Ampere relay are detailed in a two-page technical Bulletin No. 200.—*Wheelock Signals, Inc.*

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Oscilloscope

Booklet gives a presentation of high-speed laboratory oscilloscope, for observation, measurement, and photographic recording of wideband phenomena.—*Tektronix, Inc.*

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Cleaning Chemicals

Booklet titled "Chemicals for Ultrasonic Cleaning," gives information on physical properties of commonly used cleaning chemicals, as well as suggested applications, working temperatures, and procedures.—*Branson Instruments, Inc.*

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Booklet describes electro-dynamic balancing machines and their applications.—*Tinius Olsen Testing Machine Co.*

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Two-page data sheet #113 covering a 600 ampere surge test set that permits surge testing of silicon rectifiers in accordance with JAN specifications.—*Wallson Associates, Inc.*

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Transformer Catalog

Illustrated catalog describes a line of miniature toroidal transformers, inductors, magnetic amplifiers and other magnetic devices.—*Arnold Magnetics Corp.*

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Capacitors

Two-page bulletin describes new small size foil capacitors for miniaturized circuitry. Publication documents the electrical characteristics of the new capacitors.—*General Electric Co.*

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Controls Catalog

Descriptions of more than 100 electronic and electromechanical devices and systems for military aircraft, commercial transports, missiles and space vehicles.—*United Control Corp.*

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Magnetic Recorder

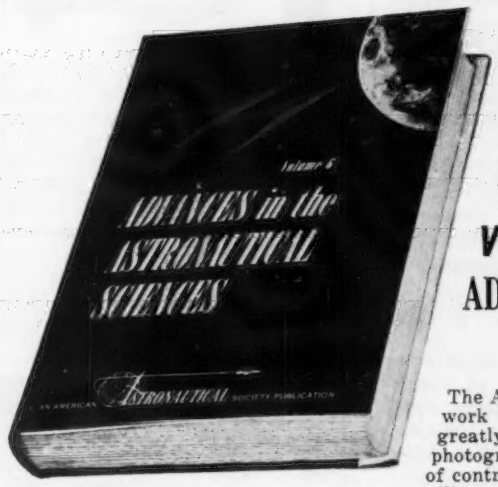
Bulletin describes airborne magnetic recorder in detail.—*Westrex Corp.*

Circle 74 on Inquiry Card for more data

Accelerometer

Description and design features of strain gage accelerometers are available in a two-page bulletin.—*Transducer Div. of Consolidated Electrodynamics Corp.*

Circle 75 on Inquiry Card for more data



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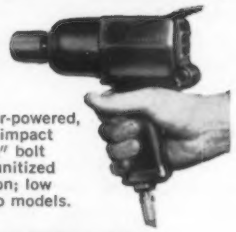

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Circle 23 on Inquiry Card

Worth Asking For

Borescopes

Bulletin describes various configurations and applications of borescopes for visual internal inspection. —*Lenox Instrument Co.*

Circle 76 on Inquiry Card for more data

Pump Valves

Data on check valves includes all sizes and types plus specifications on many models. — *Combination Pump Valve Co.*

Circle 77 on Inquiry Card for more data

Laminated Plastics

Basic application information and engineering data on laminated plastics and vulcanized fibre is given in this condensed catalog.—*Taylor Fibre Co.*

Circle 78 on Inquiry Card for more data

Water Separators

Technical bulletin discusses commercial and military filter-water separators and conversion kits.—*Bendix Filter Div., The Bendix Corp.*

Circle 79 on Inquiry Card for more data

Transistor Literature

"Transistor Guide for Communications Circuit Designers" presents a summary of the basic rules to be followed in designing transistorized communications circuits.—*Lansdale Div., Philco Corp.*

Circle 80 on Inquiry Card for more data

Thermocouple Data

Brochure describes small light weight units for measuring skin temperatures.—*Thermo Electric Co., Inc.*

Circle 81 on Inquiry Card for more data

Fotolist System

Automatic system for composing data on file cards into lists columns or paragraphs of reading matter.—*VariTyper Corp.*

Circle 82 on Inquiry Card for more data

Lightweight Nuts

Catalog, containing the largest, most complete selection of lightweight, all-metal, self-locking nuts for the airframe, propulsion and electronic industries.—*Kaylock Div., Kaynar Mfg. Co., Inc.*

Circle 83 on Inquiry Card for more data

Handles

Brochure 204G describes engineering data and price information on new line of aluminum, vinyl grip handles.—*TA Mfg. Corp.*

Circle 84 on Inquiry Card for more data

Cameras

Booklet offers information on facilities for research, development and manufacture of precision cameras.—*General Electric.*

Circle 85 on Inquiry Card for more data

AIRCRAFT QUALITY

GEARS

The precision meshing of gear teeth in aircraft is the expected—but the precise meshing of Fenn facilities and personnel to meet rigid or unusual gear requirements is welcomed . . . and often unexpected. Fenn not only offers you ultra-modern gear tooth facilities (spiral bevel, too) and highly skilled personnel —but a willingness to tackle the tough ones shoulder to shoulder from engineering to final inspection. The Fenn Manufacturing Co., Newington, Conn.

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FENN

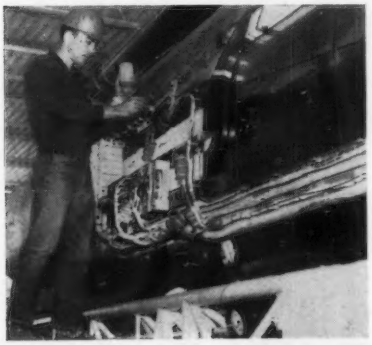
Precision Gears That Fly

Circle 24 on Inquiry Card

New Materials

Leak Detector

Fluid for use in detecting leaks in pressurized missile components, liquid oxygen systems, fuel tanks, etc. Picture shows Convair employee using



Elf Bubble Fluid to check liquid oxygen system on Atlas missile. Fluid can be poured or brushed on surface or dipping technique may be used.—Aviation Lubricants Co.

Circle 86 on Inquiry Card for more data

Silicone Fluids

Nitrile-containing silicone fluids have been developed. Presence of nitrile groups in the fluids gives them high polarity and results in such properties as solvent resistance, limited electrical conductivity and high dielectric constant. The properties of N.S. Fluids suggest their possible use of nonaqueous antifoams, base stocks for solvent resistant greases and coatings, antistatic agents, as plasticizers and additives for plastics as well as components in polish formulations. The high polarity of the nitrile group gives them insolubility in nonpolar solvents such as aliphatic and aromatic hydrocarbons. These fluids are soluble in certain polar solvents such as alcohols, ketones and ethers.—General Electric, Silicone Products Dept.

Circle 87 on Inquiry Card for more data

Aluminum Sapphire

Development work on ultra-strength composite materials that pound-for-pound are expected to be three to four times stronger at white heat than any high-strength alloy is aimed at combining aluminum with tiny "whiskers" of pure sapphire. A square inch piece of such a composite could withstand a tension of several hundred thousands of pounds. Sapphire "whiskers" are grown from pure aluminum by a special high temperature process. These whiskers are able to withstand tension varying from a few thousand to several million pounds per square inch. In size, they range from tiny woolly strands to large needles. The final objective of the work is to achieve a strength to weight ratio of 60,000 inches at 2000° F.—General Electric, Missile and Space Vehicle Dept.

Circle 88 on Inquiry Card for more data

Flame-Retardant Laminates

Flame-retardant Synthane laminated plastics are available in four new grades. Grade FR-1 is a paper-base phenolic and self-extinguishing. Grade FR-2, recommended for use in electronic and electrical components, TV transformer parts, terminal boards, arc barriers, printed circuits and switchgear and computer components, is a paper-base laminated plastic with a flame retardant phenolic resin binder. Grade FR-3, an Alpha paper-base laminate with epoxy resin binder, is a self-extinguishing material recommended for printed circuity and many electrical uses. Grade FR-4, developed especially for printed circuit and general electronic component applications, is a glass-base laminate with epoxy resin binder.—Synthane Corp.

Circle 89 on Inquiry Card for more data

Flexible Circuits

Flexible etched circuits are useful in curved or bent areas, in sliding drawer or drop-front cabinet assemblies.

Circuits are backed by Teflon, Kel-F, or polyester materials. Flexible circuits resist chemical action, making them usable in many environments.—U. S. Engineering Div., Litton Industries.

Circle 90 on Inquiry Card for more data

Thermosetting Film

Unsupported thermosetting elastomeric-phenolic adhesive film designed for service temperatures ranging from minus 67° F to plus 300° F with excellent flexibility, peel and shear strengths. Adhesive film has proven resistance to ozone, acids, water, jet fuels ammonia and many other corrosive or deteriorating media. Designed for metal-to-metal bonding and

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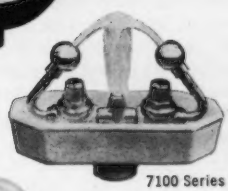

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7100 Series

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7900 Series—Maximum coverage eye/face-wash. 6 spray outlets in extra large stainless steel bowl set up soft, drenching mist for positive first aid. Large hand valve.

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Circle 25 on Inquiry Card

New Materials

sealing operations, this adhesive film provides shear strengths of over 4000 psi at 70° and over 1650 psi at 300° F. 3 M Scotch-Weld film adhesive AF-30 was used in sealing the Inconel and aluminum bulkheads of the X-15 liquid ammonia tank.—Minnesota Mining and Mfg. Co.

Circle 91 on Inquiry Card for more data

Silicone Rubber

Fluid silicone rubber cures at room temp and is available in flowable and nonflowable forms. The flowable RTV can be poured over patterns of most materials providing a mold for short production runs or the making of prototypes. It is also used for potting and encapsulating delicate electronic components. Nonflowable Silastic RTV is adhesive. It has been used as a general purpose sealant in extreme environmental conditions. Silastic RTV retains flexibility over a temp rang of −70° to 500° F.—Dow Corning Corp.

Circle 92 on Inquiry Card for more data

Intumescent Coating

An intumescent coating has protected a Titan I second stage thrust chamber skirt from rocket blast damage. The flame resistant coating, a fraction of an inch in thickness, was applied to the trailing edge of the thrust chamber's ablative skirt.

The skirt is an asbestos/phenolic fiberglass laminate, used as the lower section of the thrust chamber. The Dynam-Therm D-65 coating is a phosphate and boron chemical dispersion in a polyurethane binder. Under heat, the coating becomes intumescent. Charred coating can be scraped away and a new coating applied to the same surface.—Dyna-Therm Chemical Corp.

Circle 93 on Inquiry Card for more data

Film-Forming Resin

Acrylic film-forming resin known as Carboset 511 is a water solution of an acrylic polymer that dries at room temperature to a clear, water-insoluble film. It is supplied as a 45 per cent solution in water but is also available in alcohol solution. Indications are that thin films of Carboset 511 can be used to protect polished metal during shipment. When ready for use, the film can be removed with a mild alkali.—B. F. Goodrich Chemical Co.

Circle 94 on Inquiry Card for more data

Copper Clad Micarta

Fire-retardant, cold punch copper clad laminates, paper-base phenolics of XXXPC grade for small circuits or miniaturization, have high bond

HOBART

Custom-made 28 volt D.C. Ground Power serves for starting the

MACE missile

...meets Martin's rigid requirements

Used for starting the engines on the TM-76 Mace Tactical Missile at hardsites, Hobart's 1500 ampere D.C. generator has met the Martin Company and U.S. Air Force specifications. Successful tests by Martin of the unit and missile have recently been completed.

Current work in space vehicle design indicates a growing need for a ground source of precise 28 volt D.C. power.

Spectacular features of this unit are its 0.01 second response time (achieved by conventional design techniques) and the use of proven circuits to satisfy the prime requirement of reliability in ground support.

You'll find a model to meet your needs for either D.C. or 400 cycle—motor or engine driven—generators.

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Circle 26 on Inquiry Card

strength and high solder resistance. Laminate is recommended for use in automatic fabrication processes. Laminates have passed five-second flame-out test.—Micarta Div., Westinghouse Electric Corp.

Circle 95 on Inquiry Card for more data

Nuclear Reactor Tubing

Small diameter tubing of one per cent zirconium-columbium alloy has been developed for use as fuel element cladding and heat exchange tubing in nuclear reactors. Alloy tubing retains pure columbium's low nuclear cross section and resistance to corrosion by reactor coolants. Tubing in seamless form is available in sizes from .012 in. to 1.125 in. O.D. and is available in random, multiple and cut size to a maximum length of 24 ft.—Superior Tube Co.

Circle 96 on Inquiry Card for more data

Colloidal Alumina

White, free-flowing powder, consists of clusters of minute fibrils of boehmite (A100H)) alumina. Called Baymal, powder disperses and swells up in water to form a stable colloid. When dried from water on a surface, small fibrils lie flat and interlace to form a film. In one form, Baymal is hard enough to machine steel or cut glass, while in another form it can be used to improve the smoothness of a skin lotion.—E. I. Du Pont De Nemours.

Circle 97 on Inquiry Card for more data

Slippery Rubber

Rubber with self-lubricating properties developed through a graft polymerication and flourination technique, should make possible improved O-rings, Chevron seals and packings, U-packings, and lip seals for the moving parts of engines.—Quantum, Inc.

Circle 98 on Inquiry Card for more data

Hi Temp Polyamide

High temperature resistant polyamide called HT-1 shows promise for use in tires for the B-70 and other aircraft. Organic fiber could also be used in decelerator parachutes for space capsules. New fiber is said to extend the useful range of organic fibrous materials to 550° F.—E. I. Du Pont De Nemours.

Circle 99 on Inquiry Card for more data

Titanium Alloy

High strength alloy made by powder metallurgy processing has tensile strength of 119,000 psi; ductility; 6 per cent elongation; and hardness: Rockwell C 23. Sintered titanium alloy strength can be increased by heat treating.—Clevite Corp.

Circle 100 on Inquiry Card for more data

Aviation Adhesive

Adhesive, formulated to resist jet fuel and aviation gasoline, is designed for bonding light metal to plastic; and vinyl and cured rubber-like materials to metal, wood, ceramics and other materials. Solvent release type, cold setting adhesive is also resistant to water, oils, heat and cold.—Schwartz Chemical Co.

Circle 101 on Inquiry Card for more data

Phenolic Resins

Two new phenolic resins were developed to withstand exposure to high temperatures in missiles and space vehicles. Plyophen 23-017, is a phenolic silicone resin and 23-057, is a polyamid modified phenolic resin.—Reichhold Chemicals, Inc.

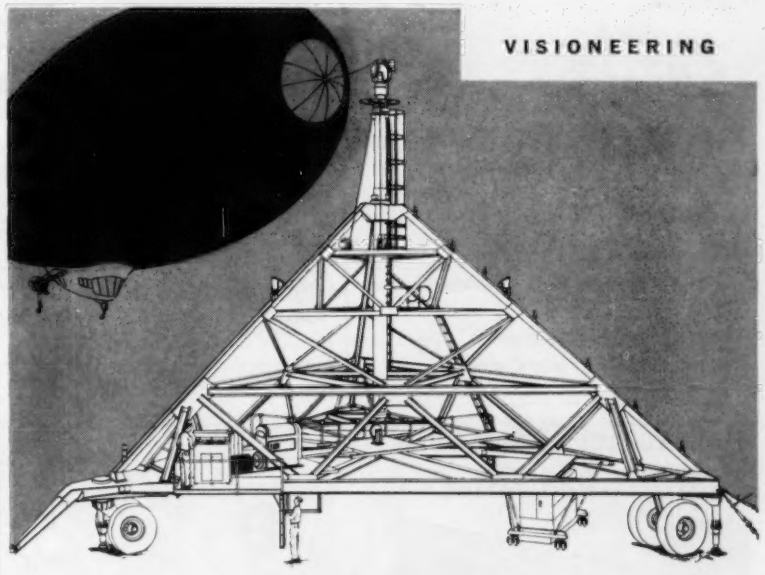
Circle 102 on Inquiry Card for more data

Casting Aluminum

New alloy was developed for use where higher yield strengths and lower elongation are required. Grade 71A, as cast and fully aged, has a yield strength of 36,000 psi and still has some degree of shock resistance. Grade 71B has a yield strength of 32,000 psi with 7 per cent elongation.—William F. Jobbins, Inc.

Circle 103 on Inquiry Card for more data

Continued page 71



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DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)
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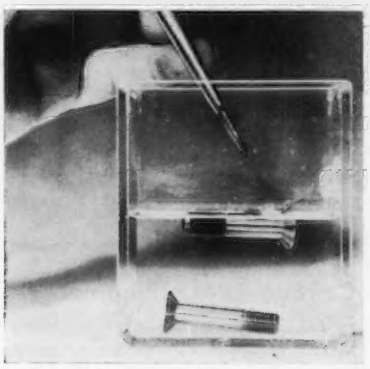
Circle 32 on Inquiry Card

New Materials

Beryllium Bolts

Beryllium bolt floats in a water solution of silver nitrate. Similar bolt made of lightweight titanium sinks, since it is two and one-half times as heavy. Steel is more than four times



the weight of the new beryllium fasteners that will be used initially to fasten space and missile craft. Liquid is silver nitrate solution with slightly greater density than water. Beryllium is not quite light enough to float in pure H_2O.—Standard Pressed Steel Co.

Circle 104 on Inquiry Card for more data

Aerospace Insulation

Insulating material called Thermosorb is composed of more than 90 per cent water. The new material has been used successfully in rockets to protect instruments and control system components located in compartments immediately adjacent to rocket motor nozzles. Temperatures on the

outer wall of the nozzle reached 2200° F but were held to less than 150° F on the cool side of the Thermosorb. A section less than half an inch thick has been held in the hand and subjected to temp. up to 4600° F from acetylene torches for several minutes without the hand becoming uncomfortably warm.—Astronautics Div., Chance Vought Corp.

Circle 105 on Inquiry Card for more data

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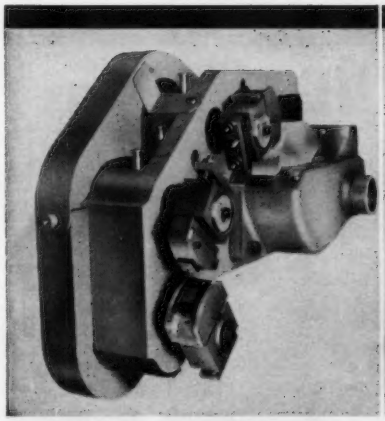
SYMBOLS, TRADEMARKS, LETTERING, NUMBERING— CONSTANT OR VARIABLE

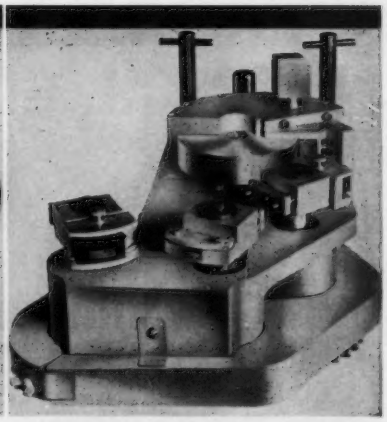
MATTHEWS *Offset* PRINTERS

WITH INTERCHANGEABLE STEEL TYPE presents a spectacular advancement in quality marking of delicate components requiring frequent changes in data, lettering or numbering. The combination of the offset printing principle plus the flexibility of a quick-change steel type holder results in the perfect marking of flat, contoured or cylindrical parts—whether constant or variable identification is required.

Matthews Offset Printers can easily be installed to fit in your present production line.



MODEL 6301 for over-the-line installation, provides identification on conveyor fed products of metal, glass, plastic and fibre.



MODEL 6302 designed as a side printer for installation adjacent to parts handling system to print parts as they pass the printer.

Write today for more information and if possible send a sample part for test marking.

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JAS. H. MATTHEWS & CO.

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Circle 30 on Inquiry Card

New Electronic Products

Portable X-ray

Compact unit's x-ray head contains both x-ray tube and transformers inside a lead-lined, shockproof and waterproof steel tank. It requires no cooling pump or special power supply.

Overall dimensions are approximately 28 x 17 x 8 in. Radiographer is positioning the Baltospot KVP x-ray unit for inspection of wing seam on a Super Constellation.—Balteau Electric Corp.

Circle 106 on Inquiry Card for more data

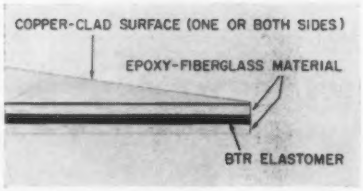
Synchronous Motor

Hysteresis synchronous motor is less than an inch in length. Designed to meet environmental requirements of MIL E 5272, it is used to provide constant speed drive for computers and navigational devices. Designated Model A3361, the 400-cycle unit has a synchronous speed of 8000 rpm. at 55 volts. Total power is 5.1 watts.—Kollsman Motor Corp.

Circle 107 on Inquiry Card for more data

Damped Printed Circuits

A new, highly damped, material for printed circuit boards, called Dynadamp, is now being offered as the first successful integrally damped material for printed circuitry. The material should help designers committed to raising reliability levels of high density electronic packages for aerospace applications. These damped laminate boards made of copper, Epoxy-Fiberglass, and a special elastomer protect circuits from electrical shorting and reduce, by more than 50 per cent, the resonant structural response that is transmitted to mounted components. The special elastomer damping layer operates over a range of from −65° F to 250° F.—Lord Mfg. Co.



Circle 108 on Inquiry Card for more data

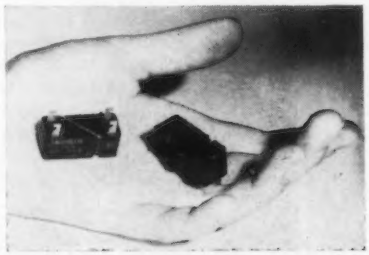
Cryogenic Thermometer

Integrated electonic cryogenic thermometer measures temp in the range of 0.3°K to 25°K. Measurements can be made without special compensation and read directly on a calibrated scale. The unit has probes designed to fit into test Dewars.—Malaker Laboratories, Inc.

Circle 109 on Inquiry Card for more data

Electric Switch

New electric switch, designed to meet MIL-S-6743 is a doublebreak, momentary contact type and is re-



turn-spring operated. Case cover and pushbutton are constructed of molded diallyll phthalate plastic. Switch will operate in temperatures from −70° C to +190° C.—General Electric Co.

Circle 110 on Inquiry Card for more data

D.C. Amplifier

D.C. differential amplifier designed for airborne instrumentation, telemetering and recording systems, supplies 0 to 5 volt output signals. Amplifier input circuit contains a static "second harmonic" magnetic modulator which converts d.c. input signals into high frequency carrier signals.—Magnetic Research Corp.

Circle 111 on Inquiry Card for more data

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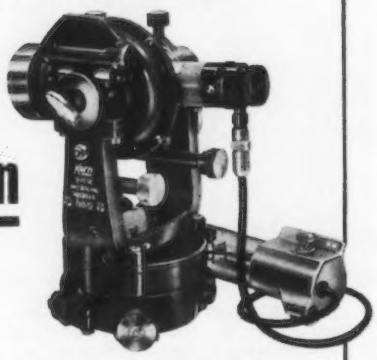
Represents one of many applications of

Autocollimation

to solve Alignment Problems of a highly precise nature.



The KERN DKM2

When equipped with the new No. 356 Autocollimating Eyepiece, this famous one-second theodolite has a total magnification of 23x and an operating range from zero to at least 100 feet for autocollimation.

Write for technical data and specifications

Kern SWISS

The FINEST in SURVEYING EQUIPMENT

KERN INSTRUMENTS INC.

120 Grand St., White Plains, N. Y.

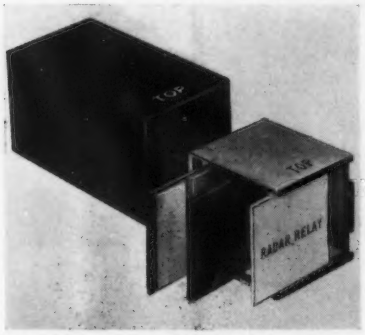
Tapped Delay Lines

Three new tapped delay lines have delay times of 3.4 usec, 1 usec and 0.5 usec. Characteristic impedance is 500 ohms. Units are encased in epoxy and measure 4.5 x 1.04 x .5 in.—HST Div., Dresser Electronics.

Circle 112 on Inquiry Card for more data

Tri-Color Display

Electronically controlled display system uses white lamps and a color filter to provide three colors in a



single indicator unit. Unit has miniaturized circuitry and components and can be mounted in compact modular arrangements.—Radar Relay, Inc.

Circle 113 on Inquiry Card for more data

Servo Analyzer

All-electronic servo analyzer measures phase and gain response on servo systems, amplifiers and other equipment. Features include a wide frequency range for both modulation and carrier frequencies, electronic modulation and inherent stability in both amplitude and frequency. Analyzer is 9½ x 24 x 15 in. and weighs 65 lbs.—Chance Vought Corp.

Circle 114 on Inquiry Card for more data

A.C.-D.C. Meters

Long-scale, 3 in. edgewise d.c. and a.c. meters have been developed for use in control console and equipment applications under severe environmental conditions. Hermetically sealed, instrument may be mounted horizontally or vertically.—Minneapolis-Honeywell.

Circle 115 on Inquiry Card for more data

Servo Analyzers

Line of solid-state dynamic servo analyzers is designed for checkout of missile and aircraft servo controls systems. Units combine the functions of signal generation, dynamic servo-response analysis, and data presentation. Analyzers are available with a choice of readouts, visual or electrical, analog or digital; and a choice of manual or automatic operation.—Giannini Controls Corp.

Circle 116 on Inquiry Card for more data

Magnetic Core Memories

Destructive and non-destructive types for airborne and space applications. Random access; linear select techniques, coupled with advanced electronic circuitry, provide two micro-second read-write cycles.

Current variations of ± 10% and temp Delta T of ± 30°C without external compensation are part of the core memory products. — Litton Systems, Inc.

Circle 117 on Inquiry Card for more data

Accumulator Test Stand

Test stand checks complete power sources automatically under conditions identical to those encountered in operational use of a missile. Operation and sequencing of the test is completely automatic and test results are graphically recorded for certification of reliability.—George L. Nankervis Co.

Circle 118 on Inquiry Card for more data

Toggle Switches

Toggle switches with no contact bounce are sealed in molded cases and provide an operating range of from -60°F to+250°F. Contact rating is 10 amps at 250 volts a.c.—Elotec Corp.

Circle 119 on Inquiry Card for more data

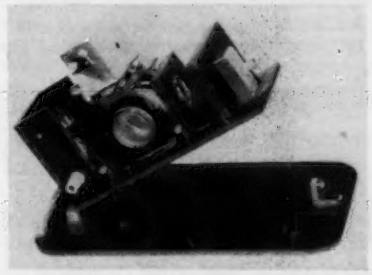
Mini Temp Transducer

Miniature precision resistance output temperature transducers for solid and liquid temperature measurement in instrumentation warning systems, telemetering, computer and testing applications, has a measuring range of -50°F to +250°F with calibrations of 5 points.—Quantatron.

Circle 120 on Inquiry Card for more data

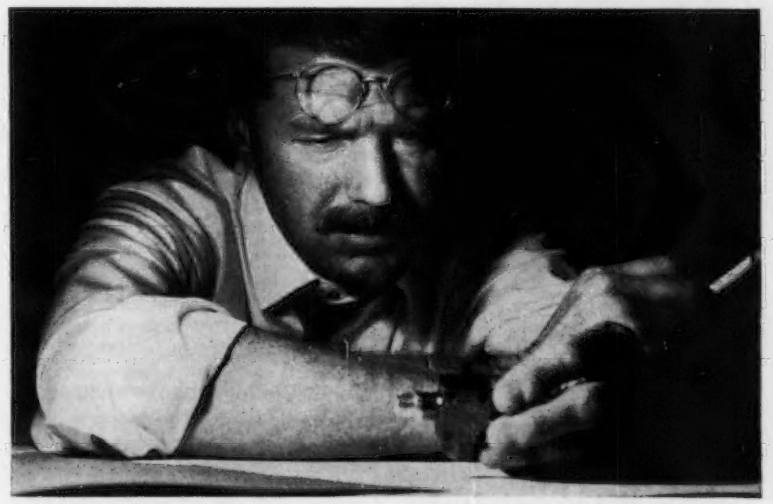
Helium Magnetometer

Metasible helium magnetometer is said to be insensitive to temp and orientation changes. Magnetometer can measure changes in the earth's field of one part in 5-million and has



a sensitivity of approximately .01 gamma. Device operates at temps from -40°F to +125°F. The basic sensing head of the device includes

Continued page 74



MAJOR PROBLEM...in Propellant-Actuated Devices?

If your problem involves combining a sizeable force with light weight for positive, instantaneous operation, talk to Horkey-Moore Associates about propellant actuated devices. HMA has a wealth of experience in space vehicle applications, aircraft escape systems and ejectors for separation of airborne stores. Cartridge-actuated pin valves, pin pullers and other mechanisms can be used in many ways to accomplish a specific task. HMA's extensive facilities for engineering, manufacturing and testing are available. Call or write today.

HORKEY-MOORE ASSOCIATES HF **Division of Houston Fearless Corp.**

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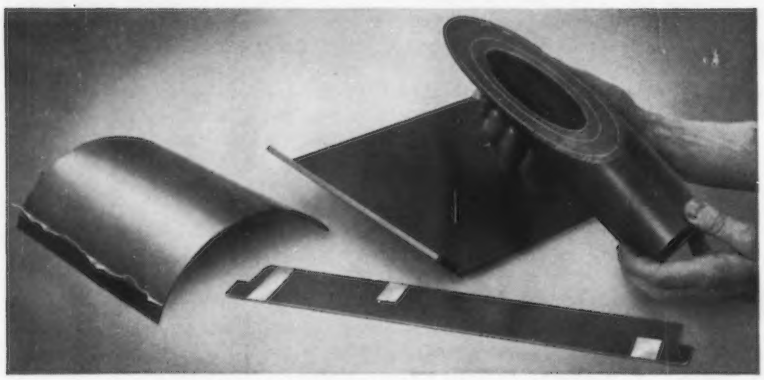
Important facts to know about laminated plastics



A few Taylor composite laminates (left to right): copper-clad section; sandwiched copper component; Taylorite vulcanized fibre-clad part; laminated tube, copper inserts.

Composite Laminates Open Up New Design Opportunities

While the great variety of commercially available laminated plastics satisfy most electrical and mechanical requirements, there are applications that can benefit from the combination of properties provided by composite laminates. Recent advances in bonding techniques have made it possible to bond virtually any compatible material with a laminate. These can be supplied as clad or as sandwiched materials. And they can be molded into many shapes to fit design requirements. Taylor is presently supplying to order the following composite laminates:

- **Copper and laminated plastics.** Clad for printed circuits and formed shapes. Sandwiched for special applications.
- **Taylorite® vulcanized fibre-clad laminates.** These combine the high strength of laminated plastics with the superior hot-arc-resistance of vulcanized fibre. They are being used in both high and low-voltage switchgear applications. Also in applications where the high impact strength of vulcanized fibre may be advantageous.
- **Rubber-clad laminates.** Almost any type of natural or synthetic rubber may be used as the cladding material. These laminates are widely used for condenser tops in wet condensers to protect the laminate against highly alkaline electrolytes. They also have application in any part where sealing or chemical resistance is needed.
- **Asbestos-clad laminates.** For applications where high heat- and arc-resistance are required.
- **Laminate-clad lead.** Lead sheets sandwiched between Grade XX paper-base laminates have been used for X-ray shields. The laminate provides strength and contributes to the high shielding properties of the lead.
- **Aluminum-clad laminates.** These have been used extensively for engraving stock. They also offer possibilities as printed-circuit material and as plate holders for X-ray machines.
- **Beryllium copper-clad laminates.** Beryllium copper is nonmagnetic and a good conductor—properties that give these laminates possibilities in many applications.
- **Stainless steel-clad laminates.** Applications where nonmagnetic properties are required. Also in certain corrosive environments where the resistance of stainless steel to attack is an asset.
- **Magnesium-clad laminates.** These laminates have been produced in 108-in.-long sheets for use as screens for X-ray operators. Weight was a factor.

Our design and production engineers are constantly developing new materials, new applications, and new procedures for fabricating laminated plastics. Our experience is yours for the asking. And if you have a problem requiring assistance or more information on composite laminates, write us. Also ask for your copy of Taylor's new guide to simplified selection of laminated plastics. Taylor Fibre Co., Norristown 50, Pa.

Taylor
LAMINATED PLASTICS VULCANIZED FIBRE

New Electronic Products

a helium lamp, a helium absorption cell and an infrared detector. It weighs six pounds and measures 13 x 7 x 7 in.—Texas Instruments, Inc.

Circle 121 on Inquiry Card for more data

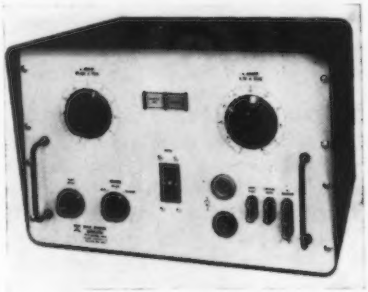
Compact Indicators

Small self-balancing indicators can be used with sensing elements connected through multi-point switches or connector panels. Chassis slides forward on built-in tracks for maintenance. Instrument requires 56 sq/in. of panel space.—Thermo Electric Co., Inc.

Circle 122 on Inquiry Card for more data

Surge Tester

Portable unit permits surge testing of silicon rectifiers with current



continuously adjustable from 25 to 630 amps. It features single half-wave sinusoidal pulse output; sync and calibrated output monitor for oscilloscope display; and provision for sequential testing.—Wallson Associates, Inc.

Circle 123 on Inquiry Card for more data

Ferrite Modulator

Absorption type ferrite modulator covers full X band of 8.2 to 12.4 kmc. It was designed for use in precision microwave measurements and communications systems.—FXR, Inc.

Circle 124 on Inquiry Card for more data

Solid-State Counter

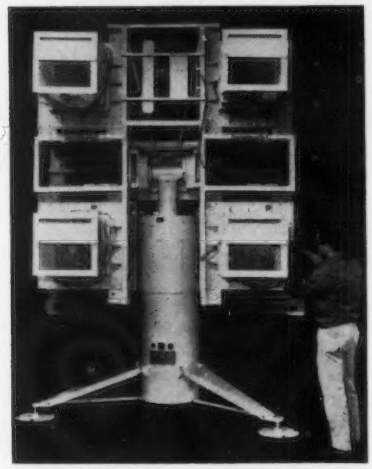
Solid-state events counter is designed to serve as a countdown device for missile range applications or for data processing. As a countdown device, the EMC-1 is synchronized with range time and counts from a minus mode thru to the plus mode. Readout is in the form of a six-place digital display.—Telmetrics, Inc.

Circle 125 on Inquiry Card for more data

New Parts and Components

Antenna Mount

Designed for use in telemetry reception, as well as tracking aircraft, missiles and satellites, the Model 10 antenna mount is a servo-controlled pedestal, for shipboard and ground



based applications, with an assembly weight of less than 600 lb. Capable of supporting 1100 lb antennas of either parabolic, endfire array or horn type the mounts are applicable either to automatic tracking systems or manual positioning operations. — Temec, Inc.

Circle 126 on Inquiry Card for more data

Finned Tubing

Integral finned small diameter tubing is produced with either straight or spiral fins, brazed or welded in place. The fin has exactly the same chemical composition as the rest of the tube. Tubing can be produced with as many as eight fins .010 to 0.30 in. in width and .010 to .100 in. in height and spiral finned tubing can be furnished with each 360-deg spiral twist repeated at intervals ranging from 5 to 12 in.—Superior Tube Co.

Circle 127 on Inquiry Card for more data

Rotary Face Seal

Beryllium copper rotary face seal for use in jet fuel and oronite systems of high performance aircraft or in other applications where unusually high pressure demands and extended temperature ranges occur. Seal is engineered for a maximum pressure differential of 10,000 psi, and temp range of −65°F to +450°F.—Hydrodyne Corp.

Circle 128 on Inquiry Card for more data

Angle Drives

Two new angle drives, the 9056HF (T-drive) and 9056-119 (Right Angle Drive) are provided with ¼ in. diameter shafts cut to a 1/16 in. flat. The drives are constructed of aluminum alloy housing steel gears, and utilize oilite bearings. They have an ultimate static torque capacity of 25 lb with a backlash of 6 deg.—F. W. Stewart Corp.

Circle 129 on Inquiry Card for more data

Filter Elements

Porous metal filter element of sintered 316 stainless steel is designed for filtration of corrosive and high temp fluids. Elements are produced by fusion of uniform stainless steel particles. They can be cleaned for re-use by firing, chemical or ultrasonic treatment, or by back flushing. —Commercial Filters Corp.

Circle 130 on Inquiry Card for more data

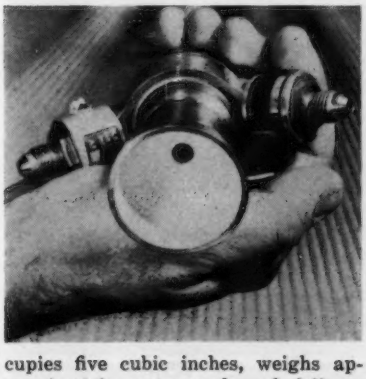
Instrument Cases

Aluminum portable carrying case features a hinged instrument mounting rail which permits equipment to be tilted out of the case 30 deg for easy viewing and operation. In the open position the hinged panel rail completely enclosed and protects the instrument with a perforated aluminum shroud, that also ventilates the instrument during operation.—Instrument Case Div., TA Mfg. Corp.

Circle 131 on Inquiry Card for more data

Pulse-Rocket Engine

Miniature pulse-rocket engine produces energy needed for precise adjustment of the position and direction of satellites. Called "Starmite," it oc-



cupies five cubic inches, weighs approximately one pound, and delivers thrust in long or short, on-off pulses at cycling rates as high as 22.5 pulses per second. Starmite is available in thrust ratings ranging from one-half to ten pounds. Engine operates on a variety of self-igniting liquid bipropellants.—Thiokol Chemical Corp.

Circle 132 on Inquiry Card for more data

Electrodynamic Shaker

Shaker with 5,000 pound force rating has built-in "piggy-back" capability for environmental testing. Features closed-loop cooling system for field and armature structures. Armature weighs 49.5 lb, with coolant. Maximum load for 10 g vector is 450 lb., for 20 g vector 200 lb. Maximum acceleration is 100 g's.—Ling-Temco Electronics, Inc.

Circle 133 on Inquiry Card for more data

Commutating Switches

Mechanical commutating switches known as the Deltaswitch Model 210 are offered in one-pole and multi-pole configurations for commutation of 64, and 100 channels of information. De-

signed for 20 cycles per second operation, switches are available with or without 1200 rpm, 115 VAC, 60 cycle synchronous hysteresis drive motors. —Advanced Technology Laboratories Div., American-Standard Corp.

Circle 134 on Inquiry Card for more data

Actuator Motor

One inch diam motor, complete with gear train, measures 2½ in. and weighs 4 ounces. Unit is designed to operate up to 1000 hours over an ambient temp range of −65° to +250° F from an input of 24-29 volts D.C. Speed is 270-280 rpm with normal rated load of 13 oz. inches.—Omega Precision, Inc.

Circle 135 on Inquiry Card for more data

Continued on page 76

New Parts and Components

Silver-Zinc Battery

Battery is used in the Titan ICBM to power the main electric circuit, servomechanisms, telemetering, propulsion and homing devices, photography, ignition, instrumentation,

range safety command and other controls.—Yardney Electric Corp.

Circle 136 on Inquiry Card for more data

Preservation Bags

Flexible preservation bags for aircraft engines will hold a vacuum or pressurization. Re-usable zippered bag can be fabricated from different materials according to the degree of vapor proofing required. — Navan Products, Inc.

Circle 137 on Inquiry Card for more data

Plastic Protectors

General purpose line of elastic polyethylene protectors can be used as a cap or plug for threaded and non-threaded parts in a range from ¼ to 2¼ in. Protector can be applied to machine screw threads, pipe threads and tubing.—S. S. White Industrial Div.

Circle 138 on Inquiry Card for more data

Subminiature Diode

Subminiature glass zener diodes for printed circuit boards and miniature circuitry are available in 5 or 10 per cent voltage tolerance types and have a max. zener impedance range from 5 to 70 ohms. Units feature glass-to-metal hermetic sealing.—International Rectifier Corp.

Circle 139 on Inquiry Card for more data

Insulated Thermostat

Insulated thermostat features wiping action and a longer bimetal actuated contact. Case is insulated by means of two glass seal solder terminals. Model BH has max. differential of less than one half per cent C. —Chatham Controls Corp.

Circle 140 on Inquiry Card for more data

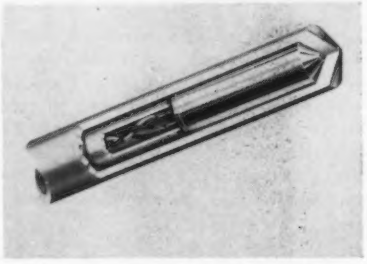
Hydraulic Swivel

All-metallic swivel was designed for use in high performance aircraft hydraulic systems. Functional temperature ranges from liquid nitrogen low to 650° F. Stainless steel swivel has pressure range up to 6000 psi.—Propulsion Development Laboratories, Inc.

Circle 141 on Inquiry Card for more data

Temp Sensor

Resistance temperature sensor for nuclear applications is designed to measure absolute or differential temperatures in the −70° to +300° C. range at radiation levels of 500 rad/hour or a total exposure of 5 x 10^7 rad, 1 MEV average. The sensing



unit of the Model 177A is hermetically sealed in a Monel K shell. Leads have braided fiberglass insulation.—Rosemont Engineering Co.

Circle 142 on Inquiry Card for more data

Lightweight Union

Light weight union for missile plumbing, called Astroweight Union, features internal sealing surfaces and a re-usable metal seal. Union utilizes an Acme thread form.—Harrison Mfg. Co.

Circle 143 on Inquiry Card for more data

Needle Valve

Compact soft seat valve for pneumatic and metering services is sealed against all gases at pressure up to 6000 psi. Valve handle and lock nut are removable for panel mounting.—Dragon Engineering Co.

Circle 144 on Inquiry Card for more data

All-Angle Blower

Panel mounting blowers feature 230-deg rotation, reversible motor-rotor assembly, 400 CFM output ca-

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Circle 13 on Inquiry Card

pacity and mount as 8¾ by 19 in. standard rack panels.—Western Devices, Inc.

Circle 145 on Inquiry Card for more data

Jet Vane Actuator

Device was engineered for use as a vernier control device in guided missiles and powered space vehicles. Unit contains electrically isolated control and telemetering data elements and features shaft-position control over a range of 25-deg. Driving member is a direct coupled D.C. torque motor.—Aeroflex Corp.

Circle 146 on Inquiry Card for more data

Extruded Sealers

Extruded rubber base sealers with cross sectional "double donut" design permit positive sealing of uneven or tapered joints, and 90-deg bending without cutting and fitting.—Minnesota Mining and Mfg. Co.

Circle 147 on Inquiry Card for more data

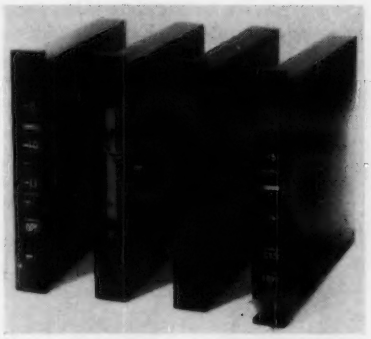
Cryostats

Cryostats cool cells of photosensitive devices to —109° F to increase detector sensitivity and usable spectrum range. Units are being manufactured for various duty cycles, varying from several seconds to several days.—Kidde Aero-Space Div.

Circle 148 on Inquiry Card for more data

Cockpit Instrument

Instrument indicators built as separate vertical parameters for aircraft cockpit instrument panels. Shown are four units: a Mach-indicated air speed indicator, an indicator of angle



of attack and acceleration, a vertical speed indicator and an altitude indicator each measuring 1⅛ in. in width, Kollsman Instrument Corp.

Circle 149 on Inquiry Card for more data

New

LIGHTWEIGHT MIRRORS

FOR AIRBORNE OPTICAL SYSTEMS & THOSE REQUIRING LOW INERTIA

Illustrated: Lightweight concave spherical mirror, 16" dia.; radius of curvature, 11"; thickness, 4"; Weight, 5 lbs., 4 oz. If of conventional solid fused quartz, it would weigh 41 lbs.!

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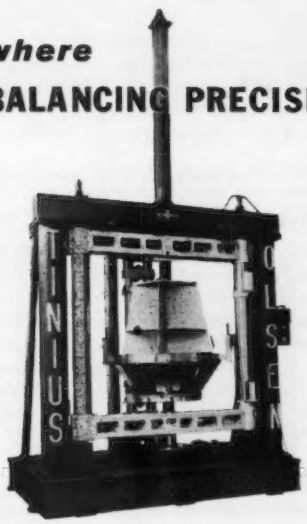

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TINIUS OLSEN

From balancing re-entry vehicles to eliminating destructive vibration in jet engines, Tinius Olsen balancing machines play a major role in the aircraft and missile industry.

If it rotates, you can balance it faster and more accurately on an Olsen. Write today for Bulletin 60, about the complete line of Tinius Olsen balancing machines.

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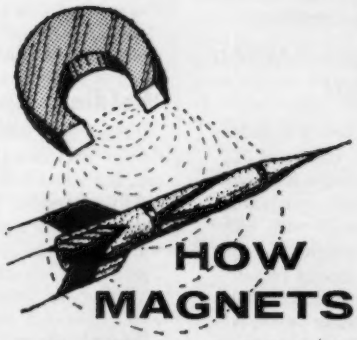
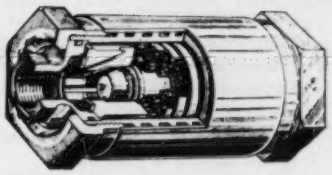


HOW MAGNETS help keep missiles and aircraft flying

FERROFILTER®

Magnetic Separators



protect fluid power systems of missiles and aircraft by removing even microscopic ferrous particles that can jam delicate, precision-made, hydraulic equipment. Shown above: Model PX-2; dry weight only 3 lbs; 3000 psi working pressure; tapped for ½" tube connection, AND-10050.

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386 Kline Ave. at Brunswick Pike
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APPROX. ACTUAL SIZE

New PACIFIC SENSING INERTIA "G" SWITCH

...provides high performance ...reliable acceleration switching!

Pacific's new inertia switch is readily adaptable to meet a variety of "G" sensing uses from missiles to freight cars. It permits a wide variation in performance and range with only a minimum of engineering and development to meet specific requirements. A unique switching action provides positive "make or break" action of the electrical contacts at the "G" setting regardless of environmental conditions.

For information on Pacific inertia switch designed to your own requirements...or on a standard unit, WRITE TODAY. The engineering skill and creative ability of Pacific Scientific are at your service.

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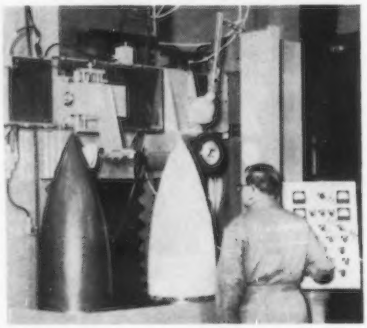
New for Production

Dual Contour Grinder

Dual-table contour grinding uses a three-dimensional master. An automatic electro-hydraulic tracer system using a master on the first table produces a duplicate on a second table.



For other applications, a grinding spindle may be added to use with the second table for grinding two identical parts, one on each table. The Model 926 machine was designed to grind Pyro-Ceram nose cones, but may be adapted for other parts.—Frauenthal Div., Kaydon Engineering Corp.

Circle 150 on Inquiry Card for more data

Welding Tip Holders

Dual spot welding electrode holder device automatically exerts equal forging pressures through its two tip-holding barrels. The equalizing mechanism is purely mechanical and a water cooling system is incorporated. The use of offset tips gives a range of distances between welds of from 0 to 4 in.—Air Reduction Sales Co.

Circle 151 on Inquiry Card for more data

Heat Treating Grids

Special grids to be used with heat treat baskets are designed to hold long pieces or special shaped material during heat treating operations. Baskets and fixtures are built to allow maximum heating or quenching rates. —Ipsen Industries, Inc.

Circle 152 on Inquiry Card for more data

Hot-Cold Chamber

Hot-cold chambers for use with tensile testers and vibrators have penetrations for the specimen holders so that the testing may be done under actual conditions of high and low temperatures which range from −100° F, obtained by using liquid CO_2, to +500° F. They are available with various types of instrumentation and controls from thermostats to program recorder controllers. A humidity attachment is also available.—Development Engineering Co.

Circle 153 on Inquiry Card for more data

Deburring Tool

Tool deburs, deflashes, and cleans tiny missile components by means of a supersonic stream of gas-propelled abrasive particles. The airbrasive tool for cutting or abrading hard, brittle materials can be used to cut shapes out of a tungsten sheet and silicon semiconductor wafers. The machine can be operated either manually or on an automated production line.—S. S. White Industrial Div.

Circle 154 on Inquiry Card for more data

Printed Circuit Cleaner

System to clean printed circuit boards mounted components was designed for production cleaning either as an automatic or manual process. Using DuPont fluorinated solvent, "Freon" cleaning agents and ultrasonic energy, the system removes activated and non-activated fluxes and other contamination from assembled printed circuits.—National Ultrasonic Corp.

Circle 155 on Inquiry Card for more data

Self-Lighting Torch

Air acetylene torch, the flame of which triggers on or off automatically without external lighting needed, can reduce gas consumption on stop and go jobs. Burning acetylene, the new torch can be used for silver brazing, soldering, and for tempering of light gauge metals.—Navan Products, Inc.

Circle 156 on Inquiry Card for more data

Horizontal Zone Refiner

Horizontal zone leveler is designed for applications such as zone leveling of germanium bars up to 18 in. long, and zone refining of such materials as potassium chloride or bromide. Furnace design lends itself to epitaxial growth along with straight diffusion processes.—Lindberg Engineering Co.

Circle 157 on Inquiry Card for more data

Vacuum Chamber

Environmental test facility for reliability testing of major sub-assemblies and large components of

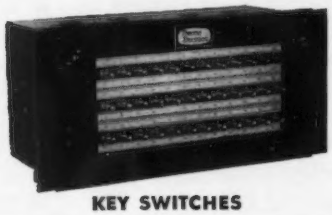
NEW Thermocouple Selector Switches

For fast, accurate indication of temperature from a number of thermocouples—to average readings from several measuring points—or to switch a thermocouple from one instrument to another—choose a new compact Thermo Electric Selector Switch.

These switches are compatible with any thermocouple or resistance thermometer, and any measuring instrument. Steel cases are dust and moisture proof, and are easily mounted on panel, rack, wall, or table.

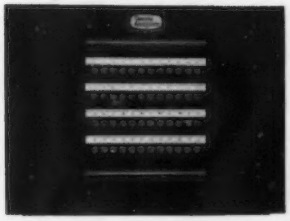
ROTARY SWITCHES

Capacities—OFF to 6, 12 or 24 measuring points. Available with binding post terminals or bunched leads for soldered connections.



KEY SWITCHES

Accommodate 1 to 144 sensing elements—locking or non-locking construction. Choose from several different cabinets.



PUSH BUTTON SWITCHES

OFF to 72 points—interlocking construction so that one switch remains "on" until another is actuated.

Write today for catalog 24-1

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

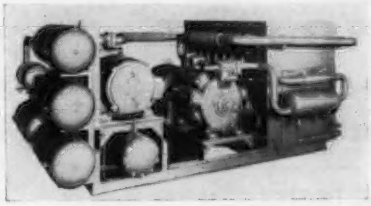
Circle 42 on Inquiry Card

space-craft, such as surveillance cameras, radio transmitters and receivers, power supplies, computers, and other electronic equipment has a work-zone 5 ft by 5 ft. A liquid-nitrogen-cooled heat-sink operating at 80°K surrounds the specimen undergoing test.—F. J. Stokes Corp.

Circle 158 on Inquiry Card for more data

Liquid Cooler

Liquid cooler which provides temperatures as low as −120° F may be used with low temperature convection fluids such as tricholoroethylene, acetone, and methylene chloride. Cooler is self-contained, with all components



mounted on a common base. Mechanical refrigeration capacity is 120,000 BTU's per hour at −100°F.—Webber Mfg. Co., Inc.

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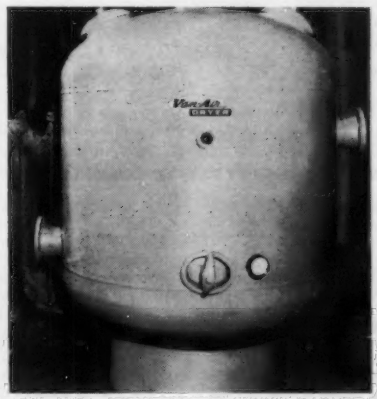
Compressed Air Dryers

Three sizes of compressed air dryers added to line brings total to 40 capacities from 7.5 to 11080 cfm at 100 psi. Designed to deliver low dewpoint air of sterile, non-toxic quality by extracting water, vapors, acid fumes and foreign particles, the dryers have several purposes: (a) protecting pneumatic equipment from corrosion, contamination and abrasion, (b) prolonging the life and accuracy of instruments and tools, (c) reducing product spoilage and rejects, (d) preventing exposed air lines from freezing. The dryers operate without heat, power or regeneration, and can be installed outdoors.—Van Products Co.



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Cost Cutting Combo

for Thermocouple Extension Wire Installations

Here's an economy team to increase efficiency and cut costs up to 75% in your next thermocouple extension wire installation. Multi-conductor THERMO-CABLE* permits you to install from 6 to 56 pairs of color-coded, insulated thermocouple leads, at one time, using just one cable. Terminate the wires in a weatherproof multi-terminal box specifically designed for THERMO-CABLE.

No more pulling individual leads through conduit. And, THERMO-CABLE, with its polyvinyl chloride weatherproof, heat and corrosion resisting outer sheath often eliminates the need for conduit. Direct burial types available to eliminate hazards from fire and mechanical damage.

T.E. weatherproof Terminal Boxes are made of cast iron or sheet steel, can accommodate from 6 to 100 circuits, and offer sure protection against the effects of contaminating atmospheres. Made to N.E.M.A. or JIC specifications.

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Please send more information about:

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Mr. Richard Bernard
RCA Service Company
Box 2578, Dept. AM-6
Van Nuys, California

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- ....1. Management
- ....2. Design & Engineering
- ....3. Production
- ....4. Procurement

B. Type of Plant or Facility

- ....1. Airframe
- ....2. Propulsion
- ....3. Electronic Systems & Parts
- ....4. Mechanical Systems & Parts
- ....5. Raw & Processed Material
- ....6. Engineering & Research Services
- ....7. Military & Government Facilities
- ....8. Parts & Supplies
- ....9. Plant or Test Equipment
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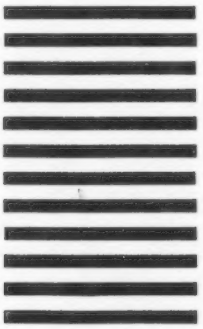

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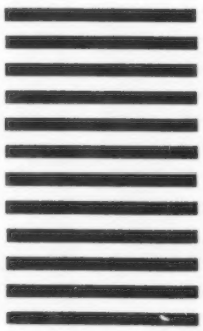

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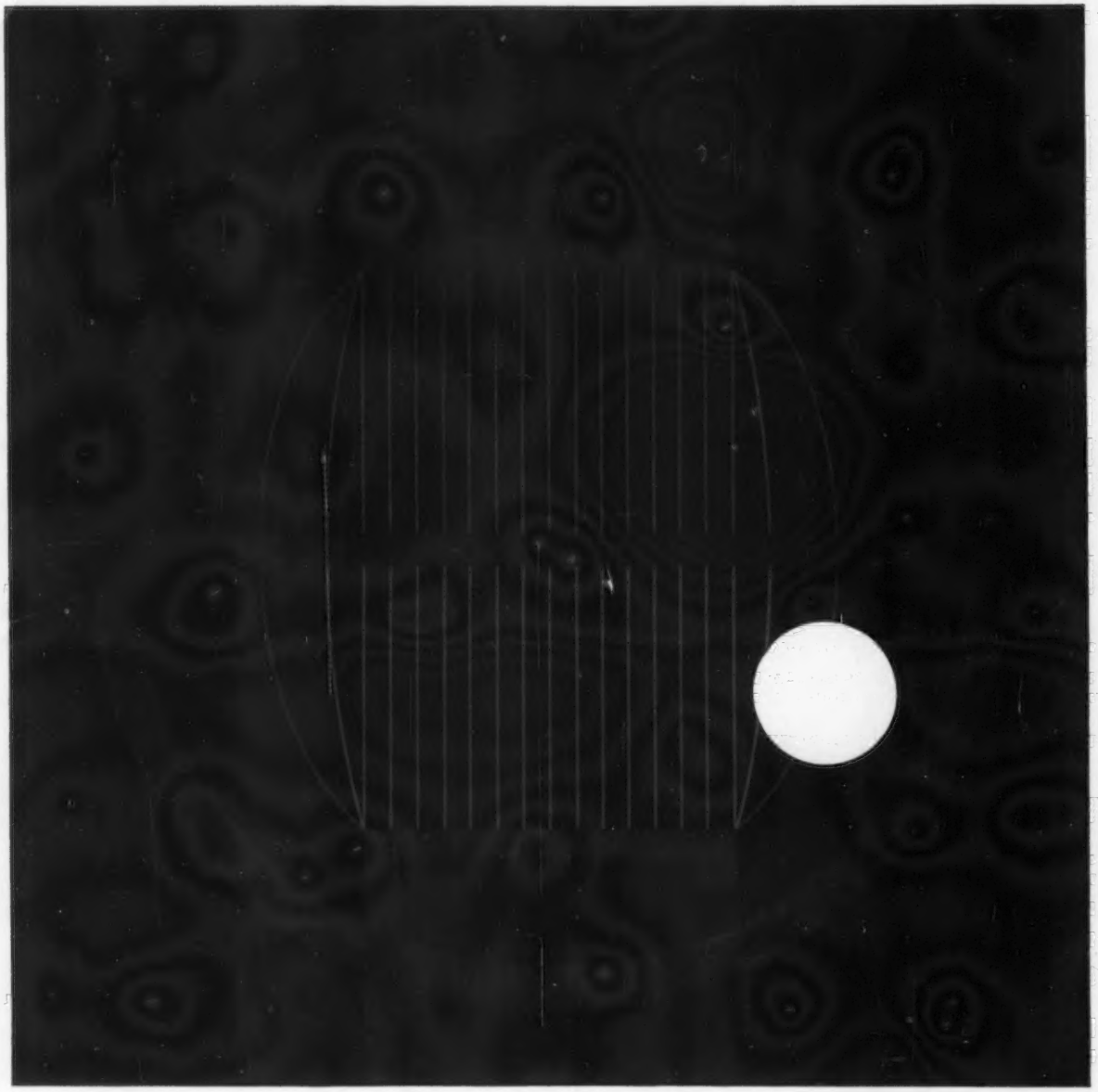

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